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FINAL REPORT

STATE-OF-THE-ART BIOLOGICAL DATA HANDBOOK

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STATE-OF-THE-ART BIOLOGICAL DATA HANDBOOK

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

FOREWORD

This report summarizes the work performed by the Lockheed Missiles and Space Company (LMSC), Sunnyvale, California, in partial fulfillment of the requirements of the National Aeronautics and Space Administration Contract NAS2-2479, "Study of Spacecraft On-Board Test and Data Processing Techniques". This contract was initiated under NASA Task No. 125-24-02-03, and administered under the cognizance of Mr. Richard O. Fimmel, Systems Engineering Division of Ames Research Center, Moffett Field, California.

The work was performed by the Data Systems Department of the Information Technology Group, Research and Development Division, LMSC. It was performed under the direction of Mr. Raymond A. Yocke as Project Engineer.

Other principal contributors to the Project were Messrs. M. A. McLennan, R. M. Pentz and W. A. Pearlman.

This handbook is intended to furnish the user of biological data with a convenient source of information about the characteristics of available flight-qualified or flight-eligible sensors and equipment. "Flight Eligible" is used to indicate designs that are flight-qualifiable but that at the time the report data was gathered had not passed qualification tests. It will also enable the average data user to make a first approximation of his data system size, the biological data loads, possible data compression techniques and telemetry system capabilities.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

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Section 1
SPECIFICATION STANDARDS

This section contains the standards for the specifications of characteristics for flight-qualified or flight-eligible equipment items located during the survey phase of the "Study of Spacecraft On-Board Test and Data Processing Techniques." All entries are for important, measurable parameters encountered in biological space missions; however, not every such important measure is represented. Each entry contains the range and value of the characteristics desirable in the equipment used to obtain the specific measure.

Two distinct equipment types are represented: (1) transducers and (2) signal-conditioning amplifiers. The transducers include all primary devices used to sense variations in a physical phenomenon and provide an electrical analog as an output. This therefore excludes electrode devices used to sense and pick up biopotentials such as ECG, EEG, EMG, etc. For these measurements, the entries include in each case the specifications for the signal-conditioning amplifiers used in conjunction with the electrodes. In each instance, therefore, the standard specifications have been established for the first electrical component in the equipment series that can adversely affect the fidelity of the derived signal. It is difficult to always choose the most advantageous equipment item from the many available for certain measures (e.g., ECG, EEG). These standard specifications provide a useful tool for objective evaluation and selection of specific biological equipment. By comparing the specifications of the available equipment, a ranking in order of degree of approximation to the standard can be made and the best one chosen.

The standards were established by thoroughly evaluating each measure and determining the information to be derived therefrom. The data available in the literature and the cumulative experience of the study team personnel were then employed to prepare a draft of the pertinent specifications. This draft was reviewed by and with experts in space medicine, and modifications were incorporated where indicated. Even with this thorough procedure, the standards presented in this section are recognized as being a somewhat subjective tabulation; they will be subject to improvement when better values or criteria are made available.

1.1 TRANSDUCERS

1.1.1 Body Temperature

Spectrum:	0 to 1 cps
Range:	92°F to 106°F
Accuracy:	0.5% full scale (106°F)
Resolution:	1.5 % full-scale deviation (14°F)

1.1.2 Respiration

Minute volume:	
Spectrum:	0.2 to 10 cps
Range: (Normal to Resting)	0 to 6 liters/min
(Heavy Work)	0 to 45 liters/min
Accuracy:	5% full scale
Tidal volume:	
Spectrum:	0.2 to 10 cps
Range: (Normal)	500 cc
(Maximum)	2,500 cc
Accuracy:	5% full scale

1.1.3 Respiratory O_2

Time constant:	0.1 sec for 99% response to step change
Range:	0 to 180 mm Hg
Accuracy:	1% full scale
Resolution:	±0.5 mm Hg
Drift:	±0.5 mm Hg after warmup
Special characteristics:	Must be calibratable under operating conditions; require minimum signal conditioning; compatible with solid-state devices; must have as high an operational stability as possible; and have a high specificity.

1.1.4 Respiratory CO_2

Time constant:	0.1 sec for 99% response to step change
Range:	0 to 30 mm Hg
Accuracy:	≤ 1% full scale
Resolution:	±0.5 mm Hg
Drift:	±0.05 mm Hg after warmup
Special characteristics:	Must be calibratable under operating conditions; require minimum signal conditioning; be compatible with solid-state devices; have as high an operational stability as possible; and have high specificity.

1.1.5 O_2 Dissolved in Blood

Arterial:

Time constant:	1 sec for 99% response to step change
Range:	1 to 120 mm Hg
Accuracy:	1% full scale
Resolution:	±0.5 mm Hg
Drift:	±0.5 mm Hg after warmup

Venous:

Time constant:	1 sec for 99% response to step change
Range:	0 to 50 mm Hg
Accuracy:	1% full scale
Resolution:	±0.5 mm Hg
Drift:	±0.5 mm Hg after warmup

1.1.6 Blood Pressure

Brachial systolic:	
Range:	100 to 200 mm Hg
Accuracy:	±3% full scale
Resolution:	±3%
Brachial diastolic:	
Range:	0 to 100 mm Hg
Accuracy:	±3% full scale
Resolution:	±3%
Venous pressure:	
Range:	- 6 to + 15 mm Hg
Accuracy:	±10% full scale
Resolution:	±5%
Special characteristics:	Must be calibratable under operating conditions with high operational stability; require minimum signal conditioning; compatible with solid-state devices

1.1.7 PO_2 (Atmospheric)

Time constant:	0.1 sec for 0 to 90% of step change, critically damped
Range:	50 to 425 mm Hg
Accuracy:	±10 mm Hg
Resolution:	±5 mm Hg
Drift:	≤ ±0.5 mm Hg/min after stabilization
Desirable band in range:	75 to 175 mm Hg
Life expectancy:	4 to 6 mo between service
Environmental conditions:	-60°F to 120°F Predictable and stable operation with variations in P_T, vibration, shock, acceleration, acoustic loading, and gravity factors
Specificity:	Must be nonsensitive to other gases

1.1.8 PCO_2 (Atmospheric)

Time constant:	0.1 sec for 0 to 99% of step change, critically damped
Range:	0 to 75 mm Hg
Accuracy:	±1 mm Hg
Resolution:	±0.5 mm Hg
Drift:	≤ 0.04 mm Hg/hr after initial stabilization
Desirable band in range:	2 to 15 mm Hg
Life expectancy:	4 to 6 mo between service
Environmental conditions:	-60°F to 120°F Predictable and stable operation with variations in P_T, vibration, shock, acceleration, acoustic loading, and gravity factors
Specificity:	Must be nonsensitive to other gases

1.1.9 PH_2O (Atmospheric)

Time constant:	≤ 1 min
Range:	0 to 100% R.H.
Accuracy:	±10% full scale
Resolution:	±5% full scale
Drift:	0.4% /hr after initial stabilization
Desirable band in range:	20 to 80% R. H.
Life expectancy:	4 to 6 mo between service
Environmental conditions:	-60°F to 120°F Predictable and stable operation with variations in P_T, vibration, shock, acceleration, acoustic loading, and gravity factors

1.2 SIGNAL CONDITIONERS

1.2.1 ECG

Spectrum:	
Status monitoring:	0.1 to 100 cps, 12 db/octave rolloff
Experimental band:	0.1 to 180 cps, 12 db/octave rolloff
Phase characteristics:	
Status monitoring:	$\leq$ 20 deg at 0.6 cps, relative to midrange
Experimental:	45 deg at 0.1 and 150 cps, relative to midrange
Resolution:	$\leq$ 1%
Gain stability:	< 5%, long and short term, absolute amplitude relatively unimportant
Linearity:	$\leq$ 1% from best straight line
Harmonic distortion:	< 2% over frequency range
Gain: (Voltage)	$\geq$ 60 db, adjustable
Transient recovery:	within 3 db of set gain within 3 sec after $\pm$1-v peak pulse > 0.1-sec wide
Noise:	$\leq$ 3μv, referred to shorted input
Common-mode rejection:	> 80 db at 60 cps
Input impedance:	> 10^6 ohms differential
Output impedance:	< 1,000 ohms over frequency range

1.2.2 EEG

Spectrum:	
Status:	0.5 to 80 cps, 12 db/octave rolloff
Experimental:	0.1 to 1 kc, 12 db/octave rolloff
Phase characteristics:	
Status:	$\leq$ 20 deg at 1 cps, relative to midrange
Experimental:	45 deg at 0.1 and 1 kc, relative to midrange
Resolution:	$\leq$ 1%
Gain stability:	< 5%, long and short term, absolute amplitude relatively unimportant
Linearity:	$\leq$ 1% from best straight line
Harmonic distortion:	< 1% over frequency range
Gain (Voltage):	> 80 db, adjustable
Transient recovery:	within 3 db of set gain within 3 sec after $\pm$1-v peak pulse $\geq$ 0.1-sec wide
Noise:	< 3μv peak, referred to shorted input
Common-mode rejection:	> 80 db at 60 cps
Input impedance:	> 10^6 ohms differential
Output impedance:	< 1,000 ohms over frequency range

1.2.3 EMG (Electromyograph)

Spectrum:	10 to 5,000 cps, 12 db/octave rolloff
Resolution: (Time)	$\pm$ 50 μsec
Gain stability:	< 5%, absolute amplitude in general is not desired data
Linearity:	$\leq$ 1% from best straight line
Harmonic distortion:	< 2% over frequency range
Gain (Voltage):	30 db
Noise:	< 10 v, referred to shorted input
Input impedance:	$\leq$ 10^6 ohms
Output impedance:	< 1,000 ohms over frequency range

1.2.4 Skin Response (GSR/BSR)

Basal:

Spectrum:	0 to 1 cps, 12 db/octave rolloff

Specifics:

Spectrum:	0.01 to 1 cps, 12 db/octave rolloff
Minimum sensitivity:	0.5% of basal

Remainder of specifications unknown owing to nature of measurement.

1.2.5 EOG (Electroculogram)

Spectrum:	0.1 to 150 cps, 12 db/octave rolloff

Remainder of specifications the same as for ECG.

1.2.6 Seismocardiogram

(Same as for ECG.)

1.2.7 Pulse

Rate: (derived from ECG)

Accuracy:	±5% of rate

Specifications vary depending on experimental requirements.

Section 2
EQUIPMENT SPECIFICATION DATA SHEETS

The entries in this section are the specification data sheets for flight-qualified or flight-eligible* equipment located during the survey phase of the "Study of Spacecraft On-Board Test and Data Processing Techniques." This list of equipment is incomplete, both in terms of equipment available and in specifications available on the equipment items listed. Provided in this section, however, is a concise compilation of items and specifications available in the open literature; as such, the compilation provides an excellent starting point for selecting equipment items for instrumenting biological equipment.

2.1 ORGANIZATION OF DATA ENTRIES

To facilitate the use of data contained in this section, the specification sheets have been ordered in the manner described below. Three groupings of equipment items have been made. Subsection 2.3 comprises data on sensors and transducers; subsection 2.4 contains data on signal-conditioning amplifiers; and subsection 2.5 is made up of uncategorized systems. Subsections 2.3 and 2.4 are subdivided into the following groups:

(1) Gas measurements (e.g., CO_2, O_2, etc.)
(2) Pressure measurements
(3) Temperature measurements
(4) Bioelectric measures (e.g., ECG, EEG, etc.)
(5) Uncategorized measures (e.g., blood velocity)

Within each of these groups are subgroups, indicated by a class code on each entry. These class codes differentiate such measures as environmental gas measures from

*"Flight eligible" is used to indicate designs that are flight-qualifiable but that at the time of the survey had not passed qualification tests.

gas dissolved in blood. For each entry in a given class, a ranking number has been assigned which was derived by comparing the characteristics of the specific item described in the entry with the standard specifications presented in Section 1.

Because of limited available data on many of the listed equipment items, it may be desirable to contact specific manufacturers or, in some cases, to examine more thoroughly the literature from which the listed data were obtained to obtain additional information. Subsection 2.6 contains a list of references from which data were gathered. The reference numbers in subsection 2.6 correspond to the reference numbers listed on the specification data sheets.

2.2 SENSORS AND TRANSDUCERS

MEASURAND	O_2
MODEL, SERIES	
MANUFACTURER	School of Aerospace Medicine, Brooks Air Force Base, Texas
OPERATING PRINCIPLE	Electrochemical
MEASURAND RANGE	0 to 1 atmosphere
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	2.5×10^{-8} amp/mm Hg
OVERRANGE FACTOR	
LIFE EXPECTANCY	Greater than 1 yr
TIME CONSTANT AND/OR FREQUENCY RESPONSE	0.25 sec for a 2-mil membrane and a temperature of 40°C is the one-time constant response time. For 99% response, 2 to 15 seconds. Relatively unaffected by shock, vibrations, and g.
ENVIRONMENTAL RANGES AND EFFECTS	Sensitivity variation with temperature – 4 to 5%/°C Thermal time constant – 2 to 3 min
ACCURACY	2 to 5% with thermistor temperature compensation, ±5% long-term unattended, ±1% frequently calibrated
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	3.5 cm diam., 2.5 cm long
c. Weight	40 grams
d. Mounting	
SPECIFICITY	Highly specific to O_2
REMARKS	Electrodes; Gold/Cadmium Electrolyte; Potassium Chloride
REFERENCE	2, Same as Ref. 7
OUTPUT VOLTAGE	40 mv
CLASS	Respiratory/Environmental
RANK	1

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	O_2
MODEL, SERIES	
MANUFACTURER	Beckman Instruments
OPERATING PRINCIPLE	Polarographic
MEASURAND RANGE	0 to 800 mm Hg partial pressure
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	25 microamp full-scale at 45°F ± 1°F
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	1 min for 90% response to step change with 10% accuracy
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	For the Mercury program
REFERENCE	19
CLASS	Respiratory/Environmental
RANK	2

MEASURAND	Oxygen
MEASURAND PROPERTIES	Measures oxygen mass flow (pneumotachometer)
MODEL, SERIES	
MANUFACTURER	North American Aviation
OPERATING PRINCIPLE	Thermistor heated to 500°F cooled by expired air
MEASURAND RANGE	0 to 140 liters/min at 55,000 ft
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	0.1 to 0.2 sec
ENVIRONMENTAL RANGES AND EFFECTS	Temperature – 0° to 130°F
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	Tidal volume is not measurable with this device
REFERENCE	14
CLASS	Respiratory/Environmental
RANK	3

MEASURAND	CO_2
MODEL, SERIES	
MANUFACTURER	Perkin Elmer Corp., Norwalk, Connecticut
OPERATING PRINCIPLE	
MEASURAND RANGE	0 to 30 mm Hg
OUTPUT CHARACTERISTICS	
a. Nature	Analog
b. Output Range(s)	
c. Power or Voltage Output	0 to 5 VDC
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	Indefinite
TIME CONSTANT AND/OR FREQUENCY RESPONSE	10 sec for 63% of step change
ENVIRONMENTAL RANGES AND EFFECTS	Range: -0 to 200°F; Effects: No indication of vibration sensitivity – being tested 5% FS sensitivity charge/PSI of P_T
ACCURACY	
RESOLUTION	
MAXIMUM STATIC ERROR (AND OF F.S. OUTPUT)	±5% of reading or 0.5 mm Hg, whichever is larger
STABILITY	
FLIGHT QUALIFICATIONS	Yes
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	0.75 watts
b. Size	33 in.^{3}
c. Weight	1.7 lb
d. Mounting	
REMARKS	Environmentally sealed package alternating (tuning fork) filters 4.1, 4.3 μ with 4.3 μ highly absorbing of CO_2. Provides square wave of IR at Indium Antimonide detector.
REFERENCE	1
CLASS	Respiratory/Environmental
RANK	1

MEASURAND	CO_2
MODEL, SERIES	
MANUFACTURER	Beckman Instruments
OPERATING PRINCIPLE	Electro/Chemical
MEASURAND RANGE	30 mm Hg-PCO_2
OUTPUT CHARACTERISTICS	
a. Nature	Analog
b. Output Range(s)	$> 10^9$ ohms
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	55 mv/decade – Change in PCO_2
OVERRANGE FACTOR	
LIFE EXPECTANCY	3 wk
TIME CONSTANT AND/OR FREQUENCY RESPONSE	3 sec minimum for 63% – Value of step change
ENVIRONMENTAL RANGES AND EFFECTS	Range: 40 to 90°F; Effects: Somewhat affected by launch vibrations
ACCURACY	±12% of Reading
RESOLUTION	
FLIGHT QUALIFICATIONS	Yes
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	Power Consumption – 1 watt
b. Size	30 in.^{3}
c. Weight	1 lb
d. Mounting	
REMARKS	
SPECIAL DESIGNS REQUIRED	Preamp – input Z 10^9 ohms with Electrometer tube CK-5886 signal condition amp. also provides voltage regulation
REFERENCE	1
CLASS	Respiratory/Environmental
RANK	2

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	CO_2
MODEL, SERIES	
MANUFACTURER	Lions Research Company
OPERATING PRINCIPLE	Radiation Absorption Ionizing current comparison device
MEASURAND RANGE	0 to 20 mm Hg – PC_{02}
OUTPUT CHARACTERISTICS	
a. Nature	Analog
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	> 10^9 ohms
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	2 wk with pre-filter. Filter must be replaced
TIME CONSTANT AND/OR FREQUENCY RESPONSE	< 30 sec for step change (99%)
ENVIRONMENTAL RANGES AND EFFECTS	Range: Temperature – 0 to 160°F; Effects: Vibration – no effect 10% FS, 0 – shift/PSI variation
ACCURACY	Full Range – ± 2 mm Hg
RESOLUTION	
REPEATABILITY	Reliable
STABILITY	
FLIGHT QUALIFICATIONS	Yes – Gemini
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	0.5 watt
b. Size	32 in.^{3}
c. Weight	2.5 lb
d. Mounting	
REMARKS	Special Characteristics: 40 cc inlet gas, split to 2 to 20 cc "Accarite" filter removes CO_2 in one channel, tritium source ionizes gases, applied voltage field causes I proportional to absorbed CO_2
REFERENCE	1
CLASS	Respiratory/Environmental
SPECIAL DESIGNS REQUIRED	Differential Amplifier – CK5886 Electrometer Tube 35 gms DRIERITE for 100% RH for 14 days
RANK	3

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	CO_2
MODEL, SERIES	
MANUFACTURER	Beckman Instruments Inc.
OPERATING PRINCIPLE	Polarographic
MEASURAND RANGE	1 to 20 mm Hg, an alarm at 8 mm Hg
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	40 mv/decade change in CO_2
OVERRANGE FACTOR	
LIFE EXPECTANCY	72 hr
TIME CONSTANT AND/OR FREQUENCY RESPONSE	4 min for 90% response to step change
TEMPERATURE COEFFICIENT	0.4 mv/°F
ENVIRONMENTAL RANGES AND EFFECTS	Vibration – up to 50 g's Temperature – controlled to 45°F ± 5°F
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	1 in. diam., 2 in. long
c. Weight	4 oz
d. Mounting	
REMARKS	Uses Quinhydrone electrode. For use in the Mercury program
REFERENCE	19
CLASS	Respiratory/Environmental
RANK	4

MEASURAND	Pressure
MODEL, SERIES	Type 4-312 Medium Range Unit and Low Range Unit
MANUFACTURER	Consolidated Electrodynamics, Transducer Division
OPERATING PRINCIPLE	Unbonded strain-gage windings connected in a four-arm bridge used as sensing element for this variable-resistance-type transducer.
MEASURAND RANGE	0 to 26 psi through 0 to 150 psi gage, absolute, and unidirectional differential types ± 16 through ± 5.0 psi bidirectional. Standard ranges: 0 to 50, 100, and 150 psi gage, absolute, and unidirectional differentials, ± 25 and ± 50 bidirectional differential.
LOW RANGE UNIT	All specifications similar to above except the following: Pressure range: 0 to 10 psi through 0 to 25 psi gage, absolute, and unidirectional differential, and 5 psi through 15 psi bidirectional differential Standard ranges: 0 to 10, 15, 25 ps, gage, absolute, and unidirectional differential, and 5, 7.5, 12.5 psi bidirectional differential Natural frequency: 3,000 cps for 10 psi (5 psid) transducers increasing logarithmically with pressure range to 5,000 cps for 25 psi (± 15 psid) transduoers
SENSITIVITY	At rated excitation, open circuit, +77°F-gage, absolute, and unidirectional transducers: 20 mv +30%, -10%, birdirectional ± 10 mv + 30%, -10%
OVERRANGE FACTOR	1.5 times rated pressure when applied for 3 min, does not cause a zero set to exceed 1% full-range output
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	Natural Frequency: 8,000 cps for 26-psi transducers, increasing logarithmically with pressure range to 17,000 cps for 150 psi transducers.
ENVIRONMENTAL RANGES AND EFFECTS	Compensated temperature range: -65°F to +250°F; Operable Temperature Range: -320°F to +300°F; Thermal zero shift: within 0.012% FR/°F over compensated temperature range. Thermal sensitivity shift: within 0.01% FR/°F-7.
ACCURACY	Residual unbalance: within ± 10% of full-range output at zero pressure, rated excitation, +77°F
RESOLUTION	Linearity and hysteresis combined effects as measured from the best straight line through the calibration points do not exceed: ± 0.5% FR - gage, absolute, and undirectional differential; ± 1.0% FR - bidirectional differential transducer.
LINEARITY	
OUTPUT IMPEDANCE	350 ohms ± 5% at 77°F
HYSTERESIS	
METROLOGICAL PARAMETERS	5 VDC or 5 VAC, rms; carrier frequency 0 to 20 kc maximum
a. Excitation	10 VDC or 10 VAC rms without damage
b. Input Impedance	350 ohms ± 5% at 77°F, 1 2-in.-diam., 3/4 in. long
c. Gage and Absolute	10 gms maximum: differential: 13 gms maximum; flange, gasket, and screws: 9 gms maximum
FLIGHT QUALIFICATIONS	Flyable
REMARKS	
RANGE	Maximum internal pressure: 75 psig
REFERENCE	9
CLASS	Pressure
RANK	1

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	Pressure/Pulse
MODEL, SERIES	
MANUFACTURER	Physio-Central Company, Inc.
OPERATING PRINCIPLE	
MEASURAND RANGE	Monitors sytolic blood pressure and pulse amplitude from the finger or toe
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	High, 1 v; low, 1 mv
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	As accurate as the arm cuff and stetheacope method of measuring blood pressure and pulse
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	1-1/2 v, D-size flashlight cells
b. Size	9-3/8 in. high, 11 in. long, 11-1/8 in. wide
c. Weight	Weights less than 19 lb
d. Mounting	
REMARKS	Completely portable. May be used for up to 8 hr without discomfort to patient
REFERENCE	8
CLASS	Pressure
RANK	2

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	Blood Pressure
MODEL, SERIES	
MANUFACTURER	For NASA Gemini – Aneroid Sphygmomanometer
OPERATING PRINCIPLE	
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	0 to 20 mv
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	0 to 20 cps
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	0.15 w
b. Size	1.5 by 2 by 3.75 in.
c. Weight	1.5 oz
d. Mounting	
REMARKS	Pressure bleed-off of cuff is 20 to 30 sec
REFERENCE	13
CLASS	Pressure
RANK	3

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	Blood Pressure
MODEL, SERIES	
MANUFACTURER	NASA Manned Spacecraft Center
OPERATING PRINCIPLE	
MEASURAND RANGE	60 to 200 mm Hg
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	Used in the Mercury program. A clinical cuff operated automatically by the command receiver or manually by the pilot. Safety circuits to prevent above 60 mm Hg operation for more than 2 min
REFERENCE	10
CLASS	Pressure
RANK	4

MEASURAND	Blood Pressure
MODEL, SERIES	P-23AA
MANUFACTURER	Statham Transducer, Inc.
OPERATING PRINCIPLE	Strain gage
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	Transducer positioned at the level of the catheter tip in the sorta, used with unanethesized monkeys
REFERENCE	6
CLASS	Pressure
RANK	5

MEASURAND	**Respiration**
MODEL, SERIES	
MANUFACTURER	**For the Mercury program**
OPERATING PRINCIPLE	**Thermistor heated to 200°F cooled by expired air**
MEASURAND RANGE	**±6 VDC**
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	**Similar to the X-15 unit; tidal volume cannot be measured with this unit**
REFERENCE	10
CLASS	**Respiration**
RANK	1

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	Respiration
MODEL, SERIES	
MANUFACTURER	Russian
OPERATING PRINCIPLE	Pressure Sensor
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	Rubber tube filled with powdered carbon
b. Output Range(s)	
c. Power or Voltage Output	1 to 2 ma, 0 to 2 mv
d. Output Impedance	200 to 700 ohms
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	
REFERENCE	20
CLASS	Respiration
RANK	2
SPECIFICITY	Not affected by movement or vibration

MEASURAND	Oxygen Mass Flow Pneumotachometer for the X-15 Program
MODEL, SERIES	
MANUFACTURER	
OPERATING PRINCIPLE	Heated Thermistor (500°F)
MEASURAND RANGE	0 to 140 liters/min at 35,000 ft
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	0.1 to 0.2 sec
ENVIRONMENTAL RANGES AND EFFECTS	0 to 130°F
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	Does not measure tidal volume
REFERENCE	14
CLASS	Respiration
RANK	3

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	Temperature
MODEL, SERIES	408
MANUFACTURER	Yellow Springs Instrument Co.
OPERATING PRINCIPLE	Semiconductor thermistor
MEASURAND RANGE	-110 to 300°F, -80 to 150°C
OUTPUT CHARACTERISTICS	
TRANSFER FUNCTION	7336 ohms at 0°C 1812 ohms at 30°C 560 ohms at 60°C 208.6 ohms at 90°C 155.4 ohms at 100°C
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	0.8 sec for 63% of step change
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	0.058-in. -diam. tube, 13/32-diam. disc., 10-ft cable
c. Weight	
d. Mounting	
REMARKS	Interchangeable with other YSI 400 series units ± 0.2°F Pre-aged and standardized, cannot be boiled or autoclaved
REFERENCE	3
CLASS	Temperature
RANK	1

MEASURAND	Temperature
MODEL, SERIES	409
MANUFACTURER	Yellow Springs Instrument Co.
OPERATING PRINCIPLE	Semiconductor thermistor
MEASURAND RANGE	-110 to 300°F
OUTPUT CHARACTERISTICS	
TRANSFER FUNCTION	7336 ohms at 0°C 1812 ohms at 30°C 560 ohms at 60°C 208.6 ohms at 90°C 155.4 ohms at 100°C
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	1.7 sec for 63% of step change
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	3/8-in.-diam. disc., 10-ft cable
c. Weight	
d. Mounting	
REMARKS	Interchangeable with other YSI 400 series units within ± 0.2°F pre-aged and standardized, cannot be boiled or autoclaved. Used for the X-15 skin temperature program.
REFERENCE	6
CLASS	Temperature
RANK	2

MEASURAND	Temperature
MODEL, SERIES	406
MANUFACTURER	Yellow Springs Instrument Co.
OPERATING PRINCIPLE	Ceramic Thermistor
MEASURAND RANGE	-110 to 212°F
OUTPUT CHARACTERISTICS	
TRANSFER FUNCTION	7336 ohms at 0°C 1812 ohms at 30°C 560 ohms at 60°C 208.6 ohms at 90°C 155.4 ohms at 100°C
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	2.5 sec for 63% response to step change
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	1/2-in.-diam., 10-ft cable
c. Weight	
d. Mounting	
REMARKS	Cannot be boiled or autoclaved. Pre-aged and standardized. Interchangeable with other 400 series units from YSI within 0.2°F
REFERENCE	5
CLASS	Temperature
RANK	3

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	Temperature
MODEL, SERIES	403
MANUFACTURER	Yellow Springs Instrument Co.
OPERATING PRINCIPLE	
MEASURAND RANGE	-110 to 300°F
OUTPUT CHARACTERISTICS	
TRANSFER FUNCTION	7336 ohms at 0°C 1812 ohms at 30°C 560 ohms at 60°C 208.6 ohms at 90°C 155.4 ohms at 100°C
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	3.7 sec for 63% response to step change
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	5/32-in. -diam., 10-ft cable
c. Weight	
d. Mounting	
REMARKS	Cannot be boiled or autoclaved. Pre-aged and standardized. Interchangeable with other YSI units within ± 0.2°F within the 400 series.
REFERENCE	4
CLASS	Temperature
RANK	4

MEASURAND	Temperature
MODEL, SERIES	401
MANUFACTURER	Yellow Springs Instrument Co.
OPERATING PRINCIPLE	Ceramic thermistor bridge
MEASURAND RANGE	-110 to 300°F
OUTPUT CHARACTERISTICS	
TRANSFER FUNCTION	7336 ohms at 0°C 1812 ohms at 30°C 560 ohms at 60°C 208.6 ohms at 90°C 155.4 ohms at 100°C
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	7 sec for 63% response to step change
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	3/16-in. -diam., 10-ft cable
c. Weight	
d. Mounting	
REMARKS	Cannot be boiled or autoclaved. Pre-aged and standardized. Can be interchanged with other YSI 400 series units within ± 0.2°F. Used for X-15 program, rectal temperature.
REFERENCE	3
CLASS	Temperature
RANK	5

MEASURAND	Body temperature (rectal) for the Mercury program
MODEL, SERIES	Similar to that used on the X-15
MANUFACTURER	McDonnell Aircraft
OPERATING PRINCIPLE	Thermistor (bridge)
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	3-mm-diam., 25-mm length, dipped in liquid latex to 20 cm.
c. Weight	
d. Mounting	
REMARKS	
REFERENCE	10
CLASS	Temperature
RANK	6

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	ECG
ITEM	ECG Electrode
MODEL, SERIES	
MANUFACTURER	NASA Manned Spacecraft Center
OPERATING PRINCIPLE	
ELECTRODES	No. 40 mesh stainless steel, 30-mm diam. Mounted 2 mm above skin with a Bentonite, Calcium Chloride, and water paste
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	Used in the Mercury program
REFERENCE	10 and 11
CLASS	Electrodes
RANK	1

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	ECG
ITEM	ECG Electrode
MODEL, SERIES	Used for Naval Biological Airborne and Astronautical tests
MANUFACTURER	
OPERATING PRINCIPLE	
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	No. 60 mesh metal (monel) between two sheets of molded latex having a circular aperture. Strand of cable (Mininoise manufactured by Microdot) is soldered to screen before vulcanization.
REFERENCE	15
CLASS	Electrodes
RANK	2

MEASURAND	X-15 ECG
MODEL, SERIES	
THEORETICAL TRANSFER FUNCTION	Response at 0.5 cps = 80%, Response at 60 cps = 80%, Response at 400 cps = 2%
MANUFACTURER	
OPERATING PRINCIPLE	
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	0.007 in. by 7/8 in. diam.
c. Weight	
d. Mounting	
REMARKS	Monel Metal Screen – 24 Mesh
REFERENCE	14
CLASS	Electrodes
RANK	3

MEASURAND	ECG, EEG, GSR, EOG
MODEL, SERIES	
MANUFACTURER	Russia, Used on Vostok 3 and Vostok 4
OPERATING PRINCIPLE	
MEASURAND RANGE	
ECG	Electrodes, silver discs 20 mm diam., 0.5 mm thick. Amplifier has a gain of 2,000 and a frequency passband of 0.5 to 40 cps
EEG	Amplifier has a gain of 20 and a passband of 3 to 15 cps
GSR	A 6-kc signal is modulated, detected and amplified. The electrodes are connected to the plantar surface of the right foot and lower third of the right tibia.
EOG	Silver electrodes are spring-mounted and secured to the helmet, placed near the outer corners of both eyes
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	
REFERENCE	12
CLASS	Electrodes
RANK	4

MEASURAND	Seismocardiograph
MODEL, SERIES	
MANUFACTURER	Russian
OPERATING PRINCIPLE	Seismic mass
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	Natural freq. 22 cps; Damping period 0.1 sec
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	60 by 50 by 20 mm
c. Weight	
d. Mounting	
REMARKS	Two coils with iron core immobile – Seismic mass a magnet with spring (cannot be used if animal is moving)
REFERENCE	20
SPECIFICITY	Respiratory and other slow movements have little effect
CLASS	Electrodes
RANK	5

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	EKG Paste #1
MODEL, SERIES	Used for Naval Biological Airborne and Astronautical Tests
MANUFACTURER	
OPERATING PRINCIPLE	
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	Used successfully with a special electrode Composition; 30% Beatone Sodium Chloride, 70% surgical jelly
REFERENCE	15
CLASS	Electrodes
RANK	6

TRANSDUCERS AND SENSORS DATA ACCUMULATION SHEET

MEASURAND	ECG Paste No. 2
MODEL, SERIES	Used for Naval Biological Airborne and Astronautical tests
MANUFACTURER	
OPERATING PRINCIPLE	
MEASURAND RANGE	
OUTPUT CHARACTERISTICS	
a. Nature	
b. Output Range(s)	
c. Power or Voltage Output	
d. Output Impedance	
SENSITIVITY	
OVERRANGE FACTOR	
LIFE EXPECTANCY	
TIME CONSTANT AND/OR FREQUENCY RESPONSE	
ENVIRONMENTAL RANGES AND EFFECTS	
ACCURACY	
RESOLUTION	
STABILITY	
LINEARITY	
HYSTERESIS	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	
c. Weight	
d. Mounting	
REMARKS	45% Bentonite with a 10% salt solution
REFERENCE	15
CLASS	Electrodes
RANK	6

FUNCTION	NASA Gemini Impedance Pneumography Signal Conditioning Amplifier
MANUFACTURER	
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	1 to 10% of source impedance at < -28° C to < -45° C
c. Maximum Input Level	
d. Impedance	250 to 350 ohms
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	0 to 20 mv
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0 to 6 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	Frequency response 0 to 12 cps ± 3 db
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	
LINEARITY	2 decade log., balanced
LIFE EXPECTANCY	
TRANSMITTER	
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	+10 v, -10 v, 1% DC, -6 ma, +5 ma, 0.11 watts
b. Weight	1.5 oz
c. Size	1.5 by 2 by 3.75 in.
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	Standard Balanced PCM
CLASS	Signal Conditioner, Respiration
RANK	1

FUNCTION	Signal Conditioner, Respiration
MANUFACTURER	Spacelabs Inc.
MODEL	101611
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	2 or 3 lead surface electrode
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	10 kohm min
e. Electrode Voltage	0.85 V rms, 50 kc ± 5 kc
f. Electrode Impedance	350 ohm
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Filter	6 db/octave at 10 cps
c. Impedance	Less than 1000 ohm
d. Level (Voltage, Current, Power)	0 to 5 V, single-ended
e. Bias	Internal, 2.5 V at 25°C
f. Load	Should be greater than 33 kohms
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.04 to 10 cps, coupling time constant; 4.5 sec, min
ENVIRONMENTAL RANGE	40 to 120°F
OPERATING CHARACTERISTICS	Using ECG electrodes on the chest, a voltage is applied and thoracic impedance changes due to respiration are measured.
TRANSFER FUNCTION	4 v peak-to-peak ± 0.2 v for a 10-ohm cyclic impedance change
STABILITY	± 0.1 VDC max with fixed electrodes
CONTROLS	Gain
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-11 ± 0.1 VDC, 12 ma max, 6.5 ± 0.1 VDC, 10 ma max
b. Weight	3.5 oz
c. Size	0.55 by 2.13 by 2.8 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	27
CLASS	Signal Conditioner/Respiration
RANK	2

FUNCTION	Signal Conditioner – Respiration
MANUFACTURER	Spacelabs Inc.
MODEL	150
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Electrode Voltage	0.1 volt peak-to-peak at 50 kc ± 10 kc
c. Electrode Impedance	350 ohm
d. Impedance	10 kohm at 50 kc, 10 megohm min from 0 to 100 cps
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	1,000 ohm max
d. Level (Voltage, Current, Power)	10 mv ± 1 mv differential with one output biased positive with respect to ground
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.03 to 10 cps, ± 3 db, rolloff 18 db/octave
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	10 mv peak-to-peak for 1 ohm electrode change 20 mv peak-to-peak for a 10 ohm electrode change
TEMPERATURE RANGE	Operating: 0 to 150°F, Storage: -65 to 200°F
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-9.9 to 10.1 VDC, 8 ma max, 9.9 to 10.1 VDC, 8 ma max
b. Weight	3 oz
c. Size	0.41 by 2.3 by 2.4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	36
CLASS	Signal Conditioner/Respiration
RANK	3

FUNCTION	**Signal Conditioner, Respiration**
MANUFACTURER	**Spacelabs Inc.**
MODEL	**101467 Gemini Type**
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	**600 ohms**
e. Common Mode Rejection	**Greater than 10,000 min**
f. Maximum Common Mode Voltage	
g. Voltage	**0.1 v peak-to-peak across 350 ohms**
h. Electrode Excitation	**0.1 V peak-to-peak at 50 kc**
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	**Less than 1,000 ohms**
d. Level (Voltage, Current, Power)	**10 mv**
e. Visual Display	
f. Other	**Differential: biased to 0.01 V**
TIME CONSTANT	**5 sec**
FREQUENCY RESPONSE OR RESPONSE TIME	**0.03 to 10 cps**
ENVIRONMENTAL RANGE	**0 to 150°C**
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	**Nonlinear, 10 mv, peak-to-peak for a 1-ohm impedance change 20 mv for a 10-ohm change**
STABILITY	
CONTROLS	**Gain**
RESOLUTION	
DELAY TIME	
PROCESSING TIME	**N/A**
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	**N/A**
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	**-10 V, 8 ma, 10V, 8 ma**
b. Weight	**3 oz**
c. Size	**0.41 by 2.3 by 2.4 in.**
RECEIVER	**N/A**
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	**Measures transthoracic impedance change due to respiration**
REFERENCE	**52**
CLASS	**Signal Conditioner/Respiration**
RANK	**4**

FUNCTION	Signal Conditioner, Respiration
MANUFACTURER	Spacelabs Inc.
MODEL	160-101611
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	600 ohms
e. Common Mode Rejection	Greater than 10,000
f. Maximum Common Mode Voltage	
g. Voltage	0.05 volts across 350 ohms, from 2 or 3 lead electrodes
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	Less than 1,000 ohms
d. Level (Voltage, Current, Power)	5 V, single ended
e. Visual Display	
f. Other	
TIME CONSTANT	
FREQUENCY RESPONSE OR RESPONSE TIME	0.04 to 10 cps, for a 10-kohm load
ENVIRONMENTAL RANGE	30 to 130°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	4 ± 0.2 volt peak-to-peak for a 10-ohm impedance change
ACCURACY	
STABILITY	
CONTROLS	Gain
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-11 V, 12 ma, 6.5 V, 10 ma
b. Weight	3.5 oz
c. Size	0.55 by 2.13 by 2.8 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	Measures the transthoracic impedance change due to respiration
REFERENCE	51
CLASS	Signal Conditioner/Respiration
RANK	5

FUNCTION	Signal Conditioner, Respiration
MANUFACTURER	Spacelabs Inc.
MODEL	130-102200
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Voltage	0.15 v across 350 ohms, from 2 or 3 lead electrodes
c. Electrode Excitation	0.15 v at 50 kc ± 5 kc
d. Impedance	600 ohms
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single ended
b. Rate	
c. Impedance	100 kohms
d. Level (Voltage, Current, Power)	0.8 v, peak-to-peak
e. Visual Display	
f. Other	
TIME CONSTANT	6 sec
FREQUENCY RESPONSE OR RESPONSE TIME	0.03 to 10 cps
ENVIRONMENTAL RANGE	30 to 130°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	0.8 v, peak-to-peak for a 10-ohm change
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-12 VDC, 7 ma, 6 VDC, 7 ma
b. Weight	4.5 oz
c. Size	5/8 by 2-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	This system measures the impedance change of the chest volume
REFERENCE	50
CLASS	Signal Conditioner/Respiration
RANK	6

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	Amplifier (Pneumotachometer)
MANUFACTURER	Vital Corp.
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Normal flow range	250 to 400 milliliters/sec
h. Maximum flow	8 liters/sec
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
TIME CONSTANT	0.1 sec
FREQUENCY RESPONSE OR RESPONSE TIME	0 to 2 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	22 to 27 VDC, 2 watts
b. Weight	24 oz
c. Size	3 by 5 by 1.5 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	17
CLASS	Signal Conditioner/Respiration
RANK	7

FUNCTION	Signal Conditioner – Temperature
MEASURAND PROPERTIES	Measures oral and rectal temperature
MODEL	Yellow Springs Precision Thermometer No. 44011
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	0 to 5 volts, output impedance 500 ohms
e. Visual Display	
f. Other	
STORAGE	N/A
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	Frequency response to 1 cps: 0 to -4 db at 4 cps; minimum roll-off of 17 db at 15 cps
STABILITY	1%
ACCURACY	± 0.1°F
RESOLUTION	
MEASURED AT	95°F to 105°F
FLIGHT QUALIFICATIONS	Yes
LINEARITY	± 0.3%
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	1.5 oz
c. Size	1.5 by 2 by 3.75 in.
d. Voltage	+10 to -10 VDC ± 1 percent
e. Current	5 ma/supply
f. Power	8 watts
PROBE	Finger formable and not to exceed 0.11-in. diameter. Connector will not exceed 0.25 in.
REMARKS	High-level PCM
CLASS	Signal Conditioner-Temperature
RANK	1

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	Dual Temperature Signal Conditioner
MANUFACTURER	Spacelabs Inc., Van Nuys
MODEL	Type 100443
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Thermistor Probe, Yellow Springs, 1050 ohms at 110°F, Series no. 400; 1650 ohms at 90°F
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Two: single ended – analog
b. Rate	
c. Impedance	6,000
d. Level (Voltage, Current, Power)	Adjustable Max +0.35 VDC at 110°F, -0.35 VDC at 90°F Min +0.25 VDC at 110°F, -0.25 VDC at 90°F
STORAGE	N/A
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	50°F to 110°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	± 1%
CONTROLS	Balance can be zeroed with T = 92°F to 108°F
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	1% from 90°F to 100°F with YSI series 400 probe
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-10 to -12.2 VDC at 14 ma max, +6 to +6.75 VDC at 1.0 ma max
b. Weight	3 oz
c. Size	0.5 by 1-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	29
CLASS	Signal Conditioner-Temperature
RANK	2

FUNCTION	ECG Amplifier
MANUFACTURER	Mennen-Greatbach
MODEL	621
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	150 kohms
e. Common Mode Rejection	80 db +
f. Differential Voltage Level	Normal 1 mv, Max 5 mv
g. Gain	4
h. Other	Good transient recovery
B. Specific Sensor	
OUTPUT CHARACTERISTICS	Single-ended
a. Number of Channels and Nature	
b. Rate	
c. Impedance	10kohms
d. Level (Voltage, Current, Power)	± 1 volt peak to peak
e. Noise	Less than 1 μv from 1 to 100 cps, referred to the input
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.1 to 6000 cps
ENVIRONMENTAL RANGE	-20 to +100°C operating temperature, -50 to +125°C storage, Vibration and shock meets MIL spec E-5400
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	500 to 20,000
STABILITY	0.2% from 0 to 50°C
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 6V, 1.2 ma
b. Weight	1 oz
c. Size	0.5 by 0.75 by 3.5 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	The best flight-qualified ECG amplifier available
REFERENCE	53
CLASS	ECG Signal Conditioner
RANK	1

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	ECG/EMG Signal Conditioning Amplifier
MANUFACTURER	Spacelabs Inc.
MODEL	EKG 101301 and 101299, EMG 101580
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	2 by 10^6 ohms differential
e. Common Mode Rejection	65 db at 60 cps
f. Maximum Common Mode Voltage	± 5 mv
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Noise	2.5 µv peak to peak, referred to shorted input
c. Impedance	Less than 1,000 ohms at 3 cps
d. Level (Voltage, Current, Power)	± 1 v max
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 110 cps, can be extended to 5 kc
ENVIRONMENTAL RANGE	30 to 130°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	Gain ± 2.5%
CONTROLS	Gain adjustable, 600 to 1,000
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-10 to -12.2 VDC, 2.5 ma max, 6 to 6.75 VDC, 1.5 ma max
b. Weight	3 oz
c. Size	1/2 by 1-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	24
CLASS	ECG Signal Conditioner
RANK	2

MEASURAND	NASA Gemini ECG Signal Conditioning Amplifier
MANUFACTURER	
MODEL	
INPUT CHARACTERISTICS	Matched to 1%–20 Megs term. to gnd. from 0.2 to 100 cps. 100 db common mode. Noise at output < 10 μvpp at input from DC to 100 cps
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Gain	3 to 20
c. Impedance	
d. Level (Voltage, Current, Power)	0 to 20 mv
e. Visual Display	
f. Other	Differential with resistance less than 1,000 ohms
STORAGE	
THEORETICAL TRANSFER FUNCTION	Frequency Response: 0.2 to 100 cps ± 3 db rolloff of 12 db/oct
OPERATING CHARACTERISTICS	DC coupled differential
TIME CONSTANT	Recovery time (within 2 mv of no signal) after input of 1-volt pulse for 100 millisec: 10 sec
CALIBRATION	With no signal output: 10 mv
REPEATABILITY	Stability ± 1.0%
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	+10 VDC, -10 VDC ±1%
b. Weight	1.5 oz
c. Size	1.5 by 2 by 0.375 in.
d. Power	0.1 watts
e. Current	< 5 ma/supply
REMARKS	Standard balanced PCM. The amplifier must operate from a source of 1 to 40 kc. No degradation when at 50 kc
RANK	3
CLASS	ECG Signal Conditioner

FUNCTION	Signal Conditioning Amplifier (ECG)
MANUFACTURER	
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 100 cps ± 3 db rolloff of 12 db/octaves
OUTPUT VOLTAGE	0 to 20 mv differential
OUTPUT IMPEDANCE	Less than 1,000 ohms
GAIN	3 to 20
COMMON MODE REJECTION	100 db
STABILITY	± 1%
INPUT NOISE	< 10 µv
INPUT IMPEDANCE	20 megohms
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	+10 to -10 VDC ± 1%, < 5 ma/supply 0.1 watt
b. Weight	1.5 oz
c. Size	1.5 by 2 by 3.75 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d Sensitivity	
e Noise Figure	
f. Gain	
REMARKS	For project Gemini
CLASS	ECG Signal Conditioner
RANK	4

FUNCTION	ECG Signal Conditioner
MANUFACTURER	BIOCOM, Inc.
MODEL	121
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Diff 3 lead
b. Signal Level (Normal Operation)	± 1 mv
c. Maximum Input Level	
d. Impedance	$\approx 2 \times 10^6$
e. Common Mode Rejection	80 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.1 to 10,000
ENVIRONMENTAL RANGE	25°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	60 db
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	44
CLASS	
RANK	5

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	ECG Conditioner
MANUFACTURER	Spacelabs
MODEL	150, Number in Series: 101464
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	3 lead diff
b. Signal Level (Normal Operation)	0.001 v nominal
c. Maximum Input Level	± 0.002 v
d. Impedance	> 40×10^6 ohm diff
e. Common Mode Rejection	> 80 db
f. Maximum Common Mode Voltage	± 1.0 v
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	< 1000 ohms at 3 cps
d. Level (Voltage, Current, Power)	0.01 v
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 100 cps (3 db)
ENVIRONMENTAL RANGE	0 to 150°F (operating)
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	5 to 10
STABILITY	± 5% gain
CONTROLS	Gain adjustment 5 to 10X
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-10v at 0.005, +10v at 0.005
b. Weight	2.5 oz
c. Size	0.41 by 1.5 by 2.3 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	64
CLASS	ECG Signal Conditioner
RANK	6

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	ECG Conditioner
MANUFACTURER	Biocom
MODEL	120
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Differential
b. Signal Level (Normal Operation)	0.001 v
c. Maximum Input Level	
d. Impedance	5×10^5 ohms
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Analog
b. Rate	
c. Impedance	30,000 ohms
d. Level (Voltage, Current, Power)	5v
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.4 to 5,000 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
CONSTRUCTION (EXPANDABLE)	0.5 by 0.5 by 3 in.
GAIN	6000
NOISE	3 μv noise input
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	+7 at 0.001, -7 at 0.001
b. Weight	0.5 oz
c. Size	0.675^{-3} in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	59
CLASS	ECG Signal Conditioner
RANK	7

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	**ECG Conditioner**
MANUFACTURER	**Taber Inst. Co.**
MODEL	**20264 "Telecordio Amp"**
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	**Differential**
b. Signal Level (Normal Operation)	**0.001 v nom**
c. Maximum Input Level	**0.005 v**
d. Impedance	**100 k ohms**
e. Common Mode Rejection	**> 50 db**
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	**Electrodes**
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	**Analog, balanced**
b. Rate	
c. Impedance	**< 300 ohms**
d. Level (Voltage, Current, Power)	**> 5 v rms**
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	**0.2 to 3000 cps**
ENVIRONMENTAL RANGE	**Temp 0 to 50° C 1% Vibration 60g at 60 cps**
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	**60 db gain**
STABILITY	**1% gain**
NOISE	**noise < 5 μv to input**
RESOLUTION	
DELAY TIME	
PROCESSING TIME	**N/A**
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	**N/A**
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	**± 24 v at 0.003**
b. Weight	**15 oz**
c. Size	**1-5/16 by 3-1/2 by 2-9/16 in.**
RECEIVER	**N/A**
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	**247**
CLASS	**ECG Signal Conditioner**
RANK	**6**

FUNCTION	ECG Signal Conditioner
MANUFACTURER	Vector Mfg.
MODEL	TLA-02
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Diff - 3 lead
b. Signal Level (Normal Operation)	± 1 mv
c. Maximum Input Level	
d. Impedance	> 50,000
e. Common Mode Rejection	70 db, DC-2,000
f. Maximum Common Mode Voltage	5 VDC
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single ended
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	3v
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0 to 100 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	Linearity ± 1% b.s.l.
GAIN	60 db
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	43
CLASS	ECG Signal Conditioner
RANK	9

FUNCTION	ECG or EMC Conditioner
MANUFACTURER	Taber Inst. Corp.
MODEL	2026-0
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Differential
b. Signal Level (Normal Operation)	0.001 v
c. Maximum Input Level	0.005 v
d. Impedance	> 90,000
e. Common Mode Rejection	> 50 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Analog, balanced
b. Rate	
c. Impedance	< 1000 ohms bal
d. Level (Voltage, Current, Power)	> 0.5 v rms
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	10 cps to 1,000 cps
ENVIRONMENTAL RANGE	0 to 50°F ± 5% gain
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	54 db gain
STABILITY	5% gain
NOISE	< 3 μv referred to input
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 5 v at 1.8 md
b. Weight	27 oz
c. Size	6-5/8 by 3-3/8 by 2-1/2 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	49
CLASS	ECG Signal Conditioner
RANK	10

FUNCTION	ECG Amplifier
MANUFACTURER	Taber Instrument Co
MODEL	202G-4
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	100 Kohm
e. Common Mode Rejection	50 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	5 v rms max. to CEC 7-342 galvos
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 1,000 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
GAIN	60 db
RESOLUTION	
INPUT NOISE	Less than 5 μv
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	NA
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 26.5 v at 6 ma
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	For Little Joe Project
REFERENCE	18
CLASS	ECG Signal Conditioner
RANK	11

FUNCTION	ECG Conditioner
MANUFACTURER	Spacelabs
MODEL	130, 101301
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	3 lead diff
b. Signal Level (Normal Operation)	0.001 v
c. Maximum Input Level	0.005 v
d. Impedance	2×10^6 ohms diff
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single, analog
b. Rate	
c. Impedance	< 1000 ohms at 3 cps
d. Level (Voltage, Current, Power)	± 1.0 v max
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 110 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	1,000 max
STABILITY	± 2.5% gain
CONTROLS	Gain adjustable 600 to 1000
NOISE	25 μv noise to input
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	12v at 2.4 ma, 6 v at 1.5 ma
b. Weight	3 oz
c. Size	1/2 by 1-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	50
CLASS	ECG Signal Conditioner
RANK	12

FUNCTION	ECG Amplifier
MANUFACTURER	Taber Instrument Co.
MODEL	202-3
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	2 mv peak to peak, differential
c. Maximum Input Level	
d. Impedance	100 kohms
e. Common Mode Rejection	60 db, 2 to 60 cps
f. Maximum Common Mode Voltage	0.3 volt peak
g. Remote Controls	
h. Other	Noise: < 15 μv, shorted input
B. Specific Sensor	
OUTPUT CHARACTERISTICS	Differential
a. Number of Channels and Nature	
b. Rate	
c. Impedance	< 500 ohms
d. Level (Voltage, Current, Power)	> 1 v peak to peak
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	2 to 10 k cps
ENVIRONMENTAL RANGE	0 to 50°C
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	500 ± 10%
STABILITY	5% at 25°C
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	6 VDC, 2 ma
b. Weight	4 oz
c. Size	2.2 by 1.4 by 1 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	58
CLASS	ECG Signal Conditioner
RANK	13

FUNCTION	ECG Amplifier
MANUFACTURER	Taber Instrument Co.
MODEL	202-1, 2
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	0.002 v peak to peak, differential
c. Maximum Input Level	
d. Impedance.	> 250 kohms
e. Common Mode Rejection	> 75 db, 2 to 60 cps
f. Maximum Common Mode Voltage	2 v peak
g. Remote Controls	
h. Other	Noise: < 15 μv with shorted input
B. Specific Sensor	
OUTPUT CHARACTERISTICS	Differential
a. Number of Channels and Nature	
b. Rate	
c. Impedance	< 20 kohm
d. Level (Voltage, Current, Power)	15 v peak to peak
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 45 cps
ENVIRONMENTAL RANGE	0 to 50°C operating, -55 to 85°C storage
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	3000 ± 10%
STABILITY	5% at 25°C
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 24 VDC, 5 ma
b. Weight	1.5 oz
c. Size	1.5 by 7/8 by 7/8 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	57
CLASS	ECG Signal Conditioner
RANK	14

FUNCTION	ECG Conditioner
MANUFACTURER	Spacelabs
MODEL	100433
INPUT CHARACTERISTICS	
A. General	Single channel differential
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	0.001 v
c. Maximum Input Level	
d. Impedance	< 10^6 ohms
e. Common Mode Rejection	80 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes to skin
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single analog
b. Rate	
c. Impedance	600 w
d. Level (Voltage, Current, Power)	0 to 5 v
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.3 to 100 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	52
CLASS	ECG Signal Conditioner
RANK	15

FUNCTION	ECG Conditioner
MANUFACTURER	Taber Inst. Corp.
MODEL	2026-7
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Differential
b. Signal Level (Normal Operation)	0.003 v nom
c. Maximum Input Level	
d. Impedance	> 80,000
e. Common Mode Rejection	> 50 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	Electrodes
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Analog, balanced
b. Rate	
c. Impedance	< 500 ohms
d. Level (Voltage, Current, Power)	> 0.3 v rms
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	1 to 3000 cps
ENVIRONMENTAL RANGE	25°C
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	40 db gain
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 1.5 v at 250 μd
b. Weight	1.8 oz
c. Size	2-1/16 by 1-5/8 by 11/16 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	48
CLASS	ECG Signal Conditioner
RANK	16

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	ECG Amplifier
MANUFACTURER	
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	350 ohms
d. Level (Voltage, Current, Power)	
e. Recorder	1 mv input yields 9.85 in. deflection on CEC 7-341 galvanometer
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
COMMON MODE REJECTION	1,000 to 1 at 50 cps
DIFFERENTIAL INPUT IMPEDANCE	400 kohms
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	Designed for the X-15 program
REFERENCE	14
CLASS	ECG Signal Conditioner
RANK	17

FUNCTION	ECG Signal Conditioner
MANUFACTURER	EPSCO
MODEL	124-A
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Diff 3 lead
b. Signal Level (Normal Operation)	0.001 v
c. Maximum Input Level	
d. Impedance	> 150,000 ohm
e. Common Mode Rejection	60 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	~4 mv noise at 20 K
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single ended
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.4 to 10,000
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	5 oz
c. Size	2-1/4 by 2-1/4 by 1 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	45
CLASS	ECG Signal Conditioner
RANK	18

FUNCTION	ECG Conditioner
MANUFACTURER	Biometrics, Dallas, Texas
MODEL	2033
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	0.02 watt
b. Weight	0.125 oz
c. Size	0.0005 ft^3
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	46
CLASS	ECG Signal Conditioner
RANK	19

FUNCTION	EEG Amplifier
MANUFACTURER	Spacelabs Inc.
MODEL	150
INPUT CHARACTERISTICS	
A. General	
a. Input	Differential, balanced within ±1% with respect to ground
b. Source Impedance	0 to 40 kohm
c. Maximum Input Level	
d. Impedance	5 megohm min
e. Common Mode Rejection	100 db min from 0.5 to 100 cps. 80 db min with ± 1.0 v differential offset at input
f. Input Circuit	DC coupled. Max current through source impedance < 1.0 ma
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	< 1000 ohm at 3 cps
d. Level (Voltage, Current, Power)	10 mv ± 1 mv differential with one output terminal biased positive with respect to ground
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.5 to 100 cps, ±3 db rolloff 18 db/octave above 100 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	Adjustable 100 to 150
STABILITY	±5% of gain
HARMONIC DISTORTION	Less than 1% over frequency range
NOISE	5 μv peak to peak referred to input
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-9.9 to -10.1 VDC, 5 ma max., 9.9 to 10.1 VDC, 5 ma max
b. Weight	2 oz.
c. Size	0.41 by 1.5 by 2.3 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	Designed to match typical PCM telemetry inputs or strip chart recorders. Compatible with project Gemini.
REFERENCE	35
CLASS	EEG Signal Conditioner
RANK	1

FUNCTION	EEG Preamplifier
MANUFACTURER	Spacelabs Inc., Van Nuys
MODEL	Type 100432
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	3-differential 3-lead systems
b. Signal Level (Normal Operation)	
c. Maximum Input Level	0.3 mv peak-to-peak
d. Impedance	200 kohm
e. Common Mode Rejection	45 db min at 60 cps
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	Gain: 17
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	3 lead differential
b. Rate	
c. Impedance	< 1000 kohm at 3 cps
d. Level (Voltage, Current, Power)	5 mv peak-to-peak max
e. Visual Display	
f. Other	Noise: 10 μv peak-to-peak referred to shorted inputs
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	2 to 100 cps
ENVIRONMENTAL RANGE	30°F to 130°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	Gain stability ± 5% over aperture temperature
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-10 to -12.2 VDC at 2 ma max, +6 to 6.75 VDC at 2 ma max
b. Weight	3 oz
c. Size	1/2 by 1-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	30
CLASS	ECG Signal Conditioner
RANK	2

SYSTEMS DATA ACCUMULATION SHEET

MEASURAND — **Amplifiers for Little Joe Oculometor Potentials**

MANUFACTURER

MODEL — **Same as Vector EKG amplifier except output goes to CEC 7-341 Galvos**

INPUT CHARACTERISTICS

A. General

a. Number of Input Channels and Nature
b. Signal Level (Normal Operation)
c. Maximum Input Level
d. Impedance
e. Common Mode Rejection
f. Maximum Common Mode Voltage
g. Remote Controls
h. Other

B. Specific Sensor

OUTPUT CHARACTERISTICS

a. Number of Channels and Nature
b. Rate
c. Impedance
d. Level (Voltage, Current, Power)
e. Visual Display
f. Other

STORAGE

FREQUENCY RESPONSE OR RESPONSE TIME

ENVIRONMENTAL RANGE

OPERATING CHARACTERISTICS

TRANSFER FUNCTION

ACCURACY

STABILITY

CONTROLS

RESOLUTION

DELAY TIME

PROCESSING TIME — N/A

LINEARITY

LIFE EXPECTANCY

TRANSMITTER — N/A

a. Modulation
b. Carrier Frequency
c. Subcarrier Frequency
d. Subcarrier Deviation
e. Carrier Deviation
f. Power Out
Input Power
g. Modulation Frequency
h. Carrier Stability
i. Harmonic Distortion
j. Antenna
k. Power Amplifier
l. Range
m. Bandwidth Control of Subcarrier
n. Bandwidth

METROLOGICAL PARAMETERS

a. Excitation
b. Weight
c. Size

RECEIVER — N/A

a. Bandwidth
b. Demodulators
c. Type (i. e., FM, PAM, etc.)
d. Sensitivity
e. Noise Figure
f. Gain

REMARKS

REFERENCE — 18

CLASS — Oculometor Signal Conditioner

RANK

FUNCTION	Signal Conditioner, GSR/BSR
MANUFACTURER	Spacelabs, Inc.
MODEL	101123
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	From two electrodes
b. Electrode Current	8 $\mu a/cm^2$
c. Basal Resistance Range	0 to 0.5×10^6 $ohms/cm^2$
d. Noise	4 mv rms up to 400 cps
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	Less than 1,500 ohms
d. Level (Voltage, Current, Power)	0 to 0.5 v peak-to-peak, single ended.
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	3 to 4 sec time constant, 10 sec on request
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	1,000-ohm change in skin resistance produces a 100-mv peak-to-peak signal
ACCURACY	
STABILITY	
CONTROLS	Calibration switch
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-10 to 12.2 VDC, 4 ma max, 6 to 6.15 VDC, 4 ma max
b. Weight	4.5 oz
c. Size	1/2 by 2-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	28
CLASS	GSR/BSR Signal Conditioner
RANK	

FUNCTION	Signal Conditioner
MANUFACTURER	General Precision Inc.
OPERATIONAL FORMAT	Matches inputs to PCM and FM telemetry systems
INPUT	6 types of signals (e.g., thermistor, piezoelectric, etc.) 20 channels
ENVIRONMENTAL RANGES	
a. Temperature	operating, -35 to 160°F storage, -35 to 185°F
b. Shock	90-g peak, 3.5-msec. risetime, half sine shock 18 g for 40 msec
c. Acceleration	12 g max in forward direction 3 g max in lateral direction
d. Acoustical	148 db below 300 cps 144 db max in any third octave band to 10 kc
e. Altitude	300 kft or greater
f. Vibration	0.05 (g rms)^2/cps from 20 to 300 cps increase 3 db/octave from 300 to 600 cps 0.1 (g rms)^2/cps from 600 to 1,500 cps rolloff at 12 db/octave from 1,500 to 2,000 cps
g. RFI	MIL-I-20000
STORAGE	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RELIABILITY	5,000 MTBF 71°C and 95% RH 3,500 hr MTBF 93.5°C
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
METROLOGICAL PARAMETERS	
a. Excitation	28 VDC ± 3 V, less than 1 ma
b. Weight	16 lb
c. Size	10 by 14 by 4.5 in.
REFERENCE	23
CLASS	Amplifiers, General
RANK	No ranking in this class

FUNCTION	DC Differential Amplifier
MANUFACTURER	Mennen-Greatbach
MODEL	631
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Differential
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	150 kohms
e. Common Mode Rejection	Greater than 40 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single ended or differential
b. Rate	
c. Impedance	10 kohm single ended, 20 kohm differential
d. Level (Voltage, Current, Power)	± 8 V peak-to-peak
e. Visual Display	
f. Other	Noise: Less than 1 μv DC to 100 cps, referred to input
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	DC to 6 kc
ENVIRONMENTAL RANGE	-20°C to 100°C operating, -50 to 125°C storage, Vibration and shock meets MIL Spec E 5400
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	0.02%/°C at 20 db gain; Drift less than 20 μv/°C
CONTROLS	
GAIN	5 to 360
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 12 V
b. Weight	0.1 oz
c. Size	0.4 by 0.8 by 1 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	54
CLASS	
RANK	

FUNCTION	DC Differential Amplifier
MANUFACTURER	Mennen-Greatbach
MODEL	611
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Differential
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	150 kohm
e. Common Mode Rejection	Greater than 40 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single ended or differential
b. Rate	
c. Impedance	10 kohm single ended, 20 kohm differential
d. Level (Voltage, Current, Power)	± 8 V peak-to-peak
e. Visual Display	
f. Other	Noise: less than 1 μv from DC to 100 cps, referred to input
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	DC to 6 kc
ENVIRONMENTAL RANGE	-20°C to 100°C, Vibration and shock MIL-E-5400
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	Variable 5 to 360
STABILITY	0.02%/°C at 20 db gain. Drift less than 20 μv/°C
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 12 V
b. Weight	0.25 oz
c. Size	0.4 by 0.8 by 1 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	
CLASS	55
RANK	

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	DC Amplifier
MANUFACTURER	Consolidated Electrodynamics
MODEL	1-360
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	100 kohm ± 10%
e. Common Mode Rejection	100 db min DC, 80 db min AC
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	Source Impedance: 1,000 ohms max
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Isolation	100 megohm min at 50 VDC, output to primary power ground
b. Gain	Preset to 100 to 175, or 125 to 166.6, ± 0.5%
c. Impedance	50 ohm max
d. Level (Voltage, Current, Power)	± 5 v into 50-kohm load
e. Stability	Zero drift less than 10 μv in 8 hr, referred to input
f. Noise	20 mv max peak-to-peak, from 20 to 10,000 cps, referred to input
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0 to 250 cps ± 0.1 db
ENVIRONMENTAL RANGE	
LINEARITY AND HYSTERESIS	0.05% full-scale max
TRANSFER FUNCTION	
REPEATABILITY	± 0.05% full-scale max
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	26 to 30 VDC, 100 ma max
b. Weight	
c. Size	2 by 7/8 by 2 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	38
CLASS	
RANK	

FUNCTION	General Purpose AC Amplifier
MANUFACTURER	Mennen-Greatbach
MODEL	315
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Single ended
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	Greater than 10^6 ohm
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	Good transient recovery
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single ended
b. Rate	
c. Impedance	Less than 300 ohms
d. Level (Voltage, Current, Power)	4V peak-to-peak
e. Visual Display	
f. Other	Noise: Less than 4 μv rms at 60 db gain referred to input
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	10 to 100 kcps
ENVIRONMENTAL RANGE	-20 to 100°C operating temperature, -50 to 125°C storage
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
GAIN	Variable to 60 db
STABILITY	0.04%/°C over the range 0 to 50°C
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	± 12 VDC, 1.2 ma
b. Weight	1/4 oz
c. Size	0.4 by 0.8 by 1 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	42
CLASS	
RANK	

FUNCTION	Voltage Amplifier
MANUFACTURER	Consolidated Electrodynamics
MODEL	1-302
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	200 megohm
e. Capacitance	10 picofarads max
f. Noise	broadband, 0.5 mv peak-to-peak, input shunted with 500 pf
g. Isolation	Case and shield isolated from common lead, 100 megohm min
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
GAIN	Adjustable 2 tc 25, or 20 to 90
FREQUENCY RESPONSE OR RESPONSE TIME	5 to 10,000 cps, ± 5%
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	With temperature, -65 to 165°F, ± 5% of gain With power, ± 1% of gain
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	28 VDC ± 4 v, 20 ma max
b. Weight	45 grams max
c. Mounting	two, 0.12 in. through holes on 1.5-in. centers
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	37
CLASS	
RANK	

FUNCTION	Charge Amplifier
MANUFACTURER	Consolidated Electrodynamics
MODEL	1-303
INPUT CHARACTERISTICS	
a. Max Source Capacitance	5,000 pf
b. Min Source Resistance	50 megohm
c. Noise	3 mv peak-to-peak
OUTPUT CHARACTERISTICS	
a. Reference gain	2 mv/p coulomb (reference – 500 p coulomb at 100 cps input with output load of 10k in series with 100 fd)
b. Linearity	± 2% of reference gain
c. Stability	With temperature – ± 2% of reference gain; With power – ± 1% of reference gain With Source Capacitance – Less than 2% change from 500 to 5,000 picofarads
d. Harmonic Distortion	Less than 2% when output is less than 1.77 rms
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	5 to 10,000 cps, ± 5% (with max source capacitance)
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
METROLOGICAL PARAMETERS	
a. Excitation	28 VDC, +2, -4, 5 ma max
b. Weight	25 grams max
c. Size	0.63 in. diam., 1.385 in. long
REMARKS	
REFERENCE	34
CLASS	
RANK	

2.4 UNCATEGORIZED SYSTEMS

FUNCTION	**Biotelemeter**
MANUFACTURER	**Spacelabs Inc.**
MODEL	**Biotel 150**
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature b. Signal Level (Normal Operation) c. Maximum Input Level d. Impedance e. Common Mode Rejection f. Maximum Common Mode Voltage g. Remote Controls h. Other	1 to 16 channels. Individual channel modules are used to match different physiological signals.
B. Specific Sensor	
OUTPUT CHARACTERISTICS a. Number of Channels and Nature b. Rate c. Impedance d. Level (Voltage, Current, Power) e. Visual Display f. Other	May be supplied with a 55 to 260-Mc FM receiver and appropriate sub-carrier discriminators
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	DC to 20 kc
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER a. Modulation b. Carrier Frequency c. Subcarrier Frequency d. Subcarrier Deviation e. Carrier Deviation f. Power Out Input Power g. Modulation Frequency h. Carrier Stability i. Harmonic Distortion j. Antenna k. Power Amplifier l. Range m. Bandwidth Control of Subcarrier n. Bandwidth	
METROLOGICAL PARAMETERS a. Excitation b. Weight c. Size	
RECEIVER a. Bandwidth b. Demodulators c. Type (i.e., FM, PAM, etc.) d. Sensitivity e. Noise Figure f. Gain	
REMARKS	Belt or vest pack assembly
REFERENCE	64
CLASS	N/A
RANK	N/A

FUNCTION	Biotelemeter
MANUFACTURER	Biocom Inc.
MODEL	Biolink 334-A
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	1 to 3 channels for ECG, EOG, respiration, etc.
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	500 kohm typical
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 150 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	3.8 by 1.25 by 0.8 in.
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	May be used with a modified FM receiver (88 to 108 Mc) Uses pulse-position modulation
REFERENCE	62
CLASS	N/A
RANK	N/A

FUNCTION	ECG Telemeter Transmitter
MANUFACTURER	Epsco
MODEL	124-A
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Single channel
b. Signal Level (Normal Operation)	1 mv peak-to-peak
c. Maximum Input Level	
d. Impedance	150 kohms
e. Common Mode Rejection	80 db
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	Noise: 4 μv peak-to-peak with a 20 kohm input
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	FM
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	2 mallory TR 175 batteries
b. Weight	5 oz
c. Size	2.5 by 2.25 by 1 in.
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	May be used with modified FM receiver (55 to 108 Mc)
REFERENCE	60
CLASS	N/A
RANK	N/A

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	Biotelemeter
MANUFACTURER	Avionics Research products
MODEL	Metretel transmitter 1100
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Single channel ECG
b. Signal Level (Normal Operation)	1 mv nominal
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.2 to 20,000 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i. e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	Uses a standard FM receiver (88 to 108 Mv)
REFERENCE	63
CLASS	N/A
RANK	N/A

FUNCTION	EKG Telemeter
MANUFACTURER	Telemedics
MODEL	RKG100
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Single Channel
b. Signal Level (Normal Operation)	1 mv peak-to-peak
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	10 oz
c. Size	1 by 3.5 by 4.5 in.
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	May be used with a standard FM receiver (55 to 108 Mc)
REFERENCE	61
CLASS	N/A
RANK	N/A

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	Biological Implantable Transmitter
MANUFACTURER	North American Aviation and Spacelabs Inc.
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	One channel
b. Signal Level (Normal Operation)	4 mv peak-to-peak
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	
a. Modulation	FM/FM
b. Carrier Frequency	45 Mc
c. Subcarrier Frequency	22 Kc
d. Subcarrier Deviation	± 1 to 2.5%
e. Carrier Deviation	65 Kc
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	Transmitter, 1.25 v rechargeable cell 5 ma, life of 4 hr without recharge
b. Weight	Transmitter, 2 oz
c. Size	Transmitter, 1 by 2.25 by 0.5 in.
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	The battery is recharged with an RF carrier, 66-Kc internally rectified. Charge time: 2.5 hr
REFERENCE	41
CLASS	N/A
RANK	N/A

FUNCTION	Impedance Pneumograph
MANUFACTURER	Spacelabs Inc., Van Nuys
MODEL	Type 102200
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	2 or 3 lead electrodes
b. Signal Level (Normal Operation)	
c. Electrode Voltage	0.15 v peak-to-peak, 5°, Kc ± 5 Kc
d. Electrode	200 to 600 ohms
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	Single-ended, AC-coupled
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	0.8 v peak-to-peak
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	6-sec time constant, 0.03 to 10 cps for 100-kohm load
ENVIRONMENTAL RANGE	30°F to 130°F
OPERATING CHARACTERISTICS	ECG electrode on either side of chest respiration causes impedance change
TRANSFER FUNCTION	0.8 v peak-to-peak out for 10 kohm cyclic impedance change
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	-10 v to -12.2 VDC at 7 ma max, 6 to 6.75 VDC at 7 ma max
b. Weight	4.5 oz
c. Size	5/8 by 2-1/8 by 3-3/4 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	31
CLASS	N/A
RANK	N/A

FUNCTION	Impedance Pneumograph
MANUFACTURER	Biocom Inc.
MODEL	990
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	1% change of 150 to 2 kohm
c. Maximum Input Level	
d. Impedance	500 ohms nominal
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	Less than 1,000 ohms
d. Level (Voltage, Current, Power)	0.1 v for 1% change in impedance, single-ended
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0.1 to 50 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	8 VDC, 2 ma
b. Weight	1 oz
c. Size	0.9 by 0.9 by 2.7 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	59
CLASS	N/A
RANK	N/A

FUNCTION	Phase Demodulator
MANUFACTURER	Mennen-Greatbach
MODEL	633
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	Balanced inputs
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	10 kohms
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	50 kohms at 3,000 cps
d. Level (Voltage, Current, Power)	± 2.5 v into 50 kohm load
e. Visual Display	
f. Other	Reference Signal: 12 v rms
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	-20 to 100°C
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	± 0.05%/°C
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	12 v rms center tapped, 0.6 ma
b. Weight	0.25 oz
c. Size	0.4 by 0.8 by 1 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	56
CLASS	N/A
RANK	N/A

FUNCTION	Voltage Controlled Oscillator
MANUFACTURER	Spacelabs Inc.
MODEL	To be used with model 130 transmitter
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	Adjustable for 0.5 v, 0 to 1 v, or 0 to -1 v
c. Maximum Input Level	
d. Impedance	10^5 ohms, min
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Modulation	AM, 12% max
b. Center Frequencies	IRIG channels 7 through 16
c. Impedance	2×10^4 ohms
d. Level (Voltage, Current, Power)	0.7 v peak-to-peak
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	IRIG standard for channel specified
ENVIRONMENTAL RANGE	30 to 130°F
OPERATING CHARACTERISTICS	Frequency decreases for positive-going input signal
TRANSFER FUNCTION	
ACCURACY	
STABILITY	± 2% over bandwidth and over temperature 50 to 120°F
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	N/A
LINEARITY	± 1.5% from best straight line
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	25
CLASS	N/A
RANK	N/A

FUNCTION	Aerospace Hygrometer System
MANUFACTURER	Cambridge Systems Inc.
MODEL	137S
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	Essentially zero ohms
d. Level (Voltage, Current, Power)	0 to 5 VDC, 3 ma max from 0 to 150°F
e. Visual Display	
f. Other	
RANGE	
FREQUENCY RESPONSE OR RESPONSE TIME	Less than 5 sec for 63% of a 20°F step change
ENVIRONMENTAL RANGE	0 to 150°F
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	± 1% dewpoints 32 to 150°F, ± 2% frost points 0 to 32°F
ACCURACY	
STABILITY	Temperature: ± 150 μv/°F, Drift (long term): ± 10 mv
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	
LINEARITY	± 1°F from best straight line, 0 to 2°F for line through the end points
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	28 VDC ± 4 V, 200 ma
b. Weight	697 grams
c. Size	65 in.^{3}
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	22
CLASS	N/A
RANK	N/A

FUNCTION	Miniaturized Instrumentation Package
MANUFACTURER	Hughes Aircraft Corp.
GENERAL	12 modular channels 2 differential pressure 1 ECG (V5) 3 ECG (LI, LII, LIII) 1 GSR 1 respiration 4 skin temperature
TRANSMITTER	
a. Power Out	Greater than 1 mw
b. Input power	Less than 100 mw
c. Carrier deviation	± 60 kc
d. Modulating frequency	0 to 30 kc
e. Carrier stability	± 0.025%
f. Harmonic distortion	Less than 5%
g. Carrier frequency	228.2 Mc
h. Modulation type	FM
ECG SIGNAL CONDITIONER	
a. Input noise	8 μv peak-to-peak
b. Harmonic distortion	1.5 to 5%
c. Frequency response	Less than 1 to greater than 100 cps
d. VCO frequency	± 1.5% of IRIG standard. Stability of ± 0.95%
e. Excitation	Battery 6.7 V, 1 ma for 75 hr
f. Gain stability	2.5% over 5 to 60°C
GSR SIGNAL CONDITIONER	
a. Input noise	Less than ± 0.5% peak-to-peak
b. Harmonic distortion	Less than 2.5%
c. VCO frequency	± 1.5% of IPIG standard. Stability 1.2% over 5 to 60°C
d. Gain stability	Less than ± 0.1%
HELMET AND SUIT DIFFERENTIAL PRESSURE MODULES	
a. VCO frequency	± 0.84% of IRIG standard. Stability ± 2.1% max
b. Gain stability	12.5%
RESPIRATION MEASUREMENT MODULE	
a. Output voltage	0 to 5 V
b. VCO frequency	± 0.37% of IRIG standard. Stability ± 0.033%
c. Gain stability	± 1.2%
SKIN TEMPERATURE	
a. Source impedance	1470 ohms at 100°F
b. Range of measure	80 to 120°F
c. Input noise	0.05% peak-to-peak
d. Time constant	0.2 sec
e. Harmonic distortion	Less than 1.9%
f. VCO frequency	± 0.61% of IRIG standard. Stability, ± 1.42%
g. Gain stability	± 1%
METROLOGICAL PARAMETERS	
a. Excitation	5.4 VDC, 68 ma
b. Weight	0.84 lb
c. Size	9.3 by 3.45 by 0.7 in.
REFERENCE	32

FUNCTION	Physiological Instrumentation System
MANUFACTURER	Ames Research Center NASA
MODEL	
ELECTROCARDIOGRAPH	
A. Input Characteristics	
a. Signal	Current level between electrodes 5 ma max
b. Impedance	72 kohms
c. Common Mode Rejection	10,000 to 1
B. Output Characteristics	Drives a galvonometer
C. Frequency Response	0.25 to 64 cps
D. Gain	38 db
PNEUMOGRAPH	
A. Input	Flow transducer is a strain-gage type with output linear up to 250 liters/min
B. Output	Inversely proportional to the square of the mass flow
AUTOSPHYGMOMANOMETER	
A. Input	Arm cuff, pressure source, monometer, and stethoscope used to measure blood pressure. Stethoscope connected to an amplifier with a 150- to 200-cps bandpass.
B. Output	Output of stethoscope and transducer are added together. Points are noted where sound pulses can be identified.
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	
LINEARITY	
LIFE EXPANTANCY	
REMARKS	System records electrocardiogram, pulse rate, respiration rate, systolic and diastolic blood pressures, and accelerations from 0 to 30 g's
REFERENCE	240

FUNCTION	Dosimetry
MANUFACTURER	Hughes Research Laboratories
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	Matched to 300 kohm load
d. Level (Voltage, Current, Power)	0 to 5 v
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
a. Temperature	-20 to 140°F
b. Vibration	5 to 2,000 cps white noise
c. Shock	5 to 2,000 cps white noise
d. Shock Acceleration	30 g in 9 msec
e. Acceleration	40 g for 10 min
OPERATING PRINCIPLE	Bragg-Grey
MEASURAND PROPERTIES	Measures absorbed dose at 5 places in a tissue equivalent mannikin
MEASURAND RANGE	0.01 to 100 rads/hr
SENSITIVITY	
a. 3 different channels	2.7×10^{-13} amps/rad/hr, 9.6×10^{-13} amps/rad/hr, 1.9×10^{-12} amps/rad/hr
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	39
CLASS	N/A
RANK	N/A

SYSTEMS DATA ACCUMULATION SHEET

FUNCTION	**Mass Spectrometer (Gas Analysis)**
MANUFACTURER	**Consolidated Systems Corp., Monrovia, California**
MODEL	
INPUT CHARACTERISTICS	
A. General	**Min partial pressure detectable: $< 10^{-11}$ mm Hg** **Dynamic Range: $> 10^6$**
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	**Range: 1 to 32 Atomic Mass Units, Accepts forward energy 0 to 12 electron volts side energy 12 Cv**
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	**Analog**
b. Rate	**Scans one cycle including rezero in 68 sec** **Scans 4, 14, 16, 18, 28 and 32 in 1 min**
c. Level (Voltage, Current, Power)	**0 to 5 VDC**
d. Impedance	**Feeds into TM, Z of 100 kohms to 1 megohm**
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	**0 to 40°C**
OPERATING CHARACTERISTICS	**Magnetic deflection type, double-focusing, electron-bombardment-type ion source, detects particles approaching from solid angle as large as 2π radians**
ACCURACY	
STABILITY	**± 1%: sensitivity constant within a factor of 2 over a range of operating temperature and after 500 turn-ons**
CONTROLS	
RESOLUTION	**1 part in 10^3 when $P_T = 10^{-5}$ mm Hg**
DELAY TIME	
PROCESSING TIME	
LINEARITY	
LIFE EXPECTANCY	**One yr: minimum of 500 turn-ons (14 turn-ons/day, 3 or 4 days a mo)**
TRANSMITTER	**N/A**
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	**27 watts**
b. Weight	**22 lb (excludes batteries and cables)**
c. Size	**< 0.5 ft^3**
RECEIVER	**N/A**
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	21
CLASS	N/A
RANK	N/A

FUNCTION	Intercranial Electroplethysmography
MANUFACTURER	Russian
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	0 to 8 v
e. Visual Display	
f. Other	
OPERATIONAL FORMAT	Measures variations in intercranial resistance
FREQUENCY RESPONSE OR RESPONSE TIME	
GENERAL	
a. Components Used	Master oscillator, buffer amplifier, bridge, carrier amplifier, and detector
b. Frequency	30 kc
c. Amplifier Gain	1,000 wideband and variable, with voltage giving a logarithmic response. Implanted electrodes are silver and mounted in a plexiglass plug
RESOLUTION	
EXCITATION	24 to 27 VDC, 5 to 8 ma
WEIGHT	300 grams
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	Also useful in measures without implantation on man
REFERENCE	20
CLASS	N/A
RANK	N/A

FUNCTION	Central Cardiac Monitoring System
MANUFACTURER	Spacelabs Inc., Van Nuys, Calif.
MODEL	
INPUT CHARACTERISTICS	System consists of subject borne XMT receivers Cardiac failure alarm service – visual and audio Subject location service Subject ident. device to be installed at Andrews AFB Hospital
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	Visual display of ECG graphic recorder
f. Other	Range of XMTR – 250 ft
STORAGE	Magnetic Tape Recorder
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
ACCURACY	
STABILITY	
CONTROLS	
RESOLUTION	
DELAY TIME	
PROCESSING TIME	
LINEARITY	
LIFE EXPECTANCY	5 hr on one battery charge, can be recharged
TRANSMITTER	
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	26
CLASS	N/A
RANK	N/A

FUNCTION	Electrocardiograph
MANUFACTURER	Newmark Instruments, Ltd.
MODEL	
INPUT CHARACTERISTICS	
A. General	
a. Number of Input Channels and Nature	
b. Signal Level (Normal Operation)	
c. Maximum Input Level	
d. Impedance	
e. Common Mode Rejection	
f. Maximum Common Mode Voltage	
g. Remote Controls	
h. Other	
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	0 to 60 cps
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	
TRANSFER FUNCTION	
SENSITIVITY	1 mv/cm stylus deflection
TIME CONSTANT	2 sec
TEMPERATURE RANGE	-10 to 50°C
INPUT IMPEDANCE	4 megohm
DELAY TIME	
PROCESSING TIME	
LINEARITY	
LIFE EXPECTANCY	30 ECG records before battery requires recharging
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	8 lb
c. Size	9 by 5-3/4 by 3-1/2 in.
RECEIVER	N/A
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	33
CLASS	N/A
RANK	N/A

FUNCTION	Phonocardiography
MANUFACTURER	**Russian**
MODEL	
INPUT CHARACTERISTICS	
A. General	
Amp:	
a. Gain	20,000
b. Bandwidth	50 to 500 cps
c. Integrating Network	time constant 0.02 to 0.05 sec
d. Detector	Type 47
B. Specific Sensor	
OUTPUT CHARACTERISTICS	
a. Number of Channels and Nature	
b. Rate	
c. Impedance	
d. Level (Voltage, Current, Power)	
e. Visual Display	
f. Other	
STORAGE	
FREQUENCY RESPONSE OR RESPONSE TIME	
ENVIRONMENTAL RANGE	
OPERATING CHARACTERISTICS	Separates low-frequency envelope by detection, integrates output signals. Loose freq. info. about all indices of functional condition of the cardiac muscle (duration of mechanical) electro-mechanical coeff. etc.) is determinable
RELIABILITY	A statement of "yes"
RESOLUTION	
DELAY TIME	
PROCESSING TIME	
LINEARITY	
LIFE EXPECTANCY	
TRANSMITTER	N/A
a. Modulation	
b. Carrier Frequency	
c. Subcarrier Frequency	
d. Subcarrier Deviation	
e. Carrier Deviation	
f. Power Out	
Input Power	
g. Modulation Frequency	
h. Carrier Stability	
i. Harmonic Distortion	
j. Antenna	
k. Power Amplifier	
l. Range	
m. Bandwidth Control of Subcarrier	
n. Bandwidth	
METROLOGICAL PARAMETERS	
a. Excitation	
b. Weight	
c. Size	
RECEIVER	Telephone Reciever, Type T
a. Bandwidth	
b. Demodulators	
c. Type (i.e., FM, PAM, etc.)	
d. Sensitivity	
e. Noise Figure	
f. Gain	
REMARKS	
REFERENCE	20
CLASS	N/A
RANK	N/A

FUNCTION	PO_2 dissolved in blood, gas, and other fluids
MODEL, SERIES	125A
MANUFACTURER	Instrumentation Laboratory, Inc.
INPUT CHARACTERISTICS	
a. Nature	Ranges 0 to 160 mm Hg, PO_2; 0 to 800 mm Hg, PO_2 0 to 100%, O_2
b. Signal Level (Normal Operation)	can be varied to meet sensor needs 2-100R – PO_2 Micro electrode 2-101 – PO_2 Needle electrode 2-102 – PO_2 Catheter electrode
c. Specific Sensor	This manufacturer's sensors Models 2-100R, 2-101, 2-102, 2-103 (on which no data have been obtained)
OUTPUT CHARACTERISTICS	
a. Nature	One – Analog
b. Level (Voltage, Current, Power)	1.5 VDC maximum variable at 1 ma
c. Other	Output can be single ended, push pull, floating, or grounded
d. Visual Display	Meter – 10^{-7} to 10^{-2} amp full scale
ACCURACY	1% full scale
CONTROLS	Balance, Zero Range (sensitivity)
METROLOGICAL PARAMETERS	
a. Excitation	
b. Size	10 in. by 8 in. by 8 in.
c. Weight	30 lb
d. Mounting	
REMARKS	
REFERENCE	14
CLASS	PO_2 in blood
RANK	1

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5. Ibid., Technical Bulletin – 304579

6. Ibid., Technical Bulletin – 304580

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23. Technical Bulletin on Signal Conditioner. General Precision, Inc., Aerospace Group, 63 Bedford Road, Pleasantville, New York

24. Ibid., Technical Bulletin – 130

25. Ibid., Technical Bulletin on Voltage Controlled Oscillators

26. Ibid., Technical Bulletin on Model 130 Discriminators

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28. Ibid., Technical Bulletin – 101123

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30. Ibid., Technical Bulletin – 100432

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45. Technical Bulletin 124A. Epsco, 275 Massachusetts, Cambridge, Massachusetts

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Section 3
BIOLOGICAL DATA LOADS

A key factor in attempting a data system design is the data volume or data load to be accommodated by the system. In many cases the mission is ill-defined when the data system investigation is initiated. Under these conditions, estimates of the anticipated data load are necessary. Such estimates have been made for manned and high-primate space missions and are contained in this section.

3.1 DATA LOAD VS. MISSION TYPE

To properly use the tables included in this section, a generic mission type must be selected, that is, either (1) near-earth orbit, or (2) lunar mission or planetary mission. Table 3-1 is used for near-earth orbit missions. In this table, the data are separated into Housekeeping, Exploratory and Developmental, and Environmental categories. Under each of these headings are listed the variations to be expected as a function of further mission modifications, such as crew size, mission duration, etc. By determining or assuming the projected mission type, the anticipated data loads can then be determined for near-earth orbit missions. The peak values listed in the table are indicative of the worst case real-time data load. The daily figures take into account the fact that, in general, data will not be taken on a continuous basis.

Lunar or planetary missions are not likely to be undertaken until basic life factors have been thoroughly examined. Therefore, except in the early phases of each such mission, class investigational data will not be of concern. Even when such investigational data are required, they will be of lesser volume that data for near-earth missions because most investigational problems will have been resolved during earlier missions. Table 3-2 can be used for lunar and planetary missions in the same manner as described for Table 3-1.

Table 3-1

SUMMARY OF NEAR-EARTH-ORBIT DATA LOADS*

Mission Type and Variations	Basic Physiological** Status Monitoring (Housekeeping)		Exploratory and Developmental				Assumed Environmental	
			Dynamic		Keyboard			
	Peak	Daily	Peak	Daily	Peak	Daily	Peak	Daily
Operational Mission:	5×10^3* bits/sec/ man	2×10^6* bits/day/ man	N/A		N/A		5×10^3 bits/sec	2×10^6 bits/day
Variations Due to:								
(1) Mission Duration			N/A		N/A		5×10^4 bits/sec	10^7 bits/day
(2) Crew Complement	Multiply basic load by number of men in crew		N/A		N/A			
(3) Extravehicular			N/A		10^3 bits/ day			
Investigational Mission:	5×10^3 bits/ sec man	2×10^6 bits/day	10^5 bits/sec	10^9 bits/day	10^2 bits/sec	10^5 bits/day	3×10^3 bits/sec	2×10^6 bits/day
Variations due to								
(1) Crew Complement	Multiply basic load by number of men in crew		3×10^5 bits/sec	3×10^9 bits/day	3×10^2 bits/sec	3×10^5 bits/day		
(2) No Physician or Technician			3×10^6 bits/sec	3×10^{10} bits/day	3×10^3 bits/sec	3×10^6 bits/day		
(3) High-Primate Mission	Total of all headings		3×10^9 bits/day					
(4) Extravehicular						3×10^8 bits/day		

*Bit rates based on conventional PCM system
**Calculated from 16 essential measures

Table 3-2

SUMMARY OF LUNAR AND PLANETARY MISSION DATA LOADS**

Lunar or Planetary Missions	Basic Physiological** Status Monitoring (Housekeeping)		Exploratory & Development				Assumed Environmental	
			Dynamic		Keyboard			
	Peak	Daily	Peak	Daily	Peak	Daily	Peak	Daily
Operational	5×10^3 bits/sec/man	2×10^6 bits/day/man	N/A	N/A	N/A	N/A	5×10^3 bits/sec	2×10^6 bits/day
Investigational	5×10^3 bits/sec/man	2×10^6 bits/day/man	10^4 bits/sec	10^8 bits/day	10^2 bits/sec	10^5 bits/day	5×10^3 bits/sec	5×10^6 bits/day

*Bit rates based on conventional PCM system
**Calculated from 16 essential measures

3.2 ANTICIPATED MEASURES FOR FUTURE MISSIONS

Another aspect of the data loading is knowledge of which measures will be made. Such information will influence system design in at least two areas – display, and keyboard configuration. In addition, means may be found to derive the desired information by a combination of, or computation on, other data. For these reasons, a listing of anticipated measures has been made and included here. Table 3-3 contains these anticipated measures, classed under physiological and psychological functions. Because of the overlap in many of these bodily functions, in some cases the same measure has been listed in more than one class. In addition to the psychophysiological measures, some important environmental measures are included in Table 3-3.

3.3 REFERENCES FOR SECTION 3

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ANTICIPAT
FUT

Psychological Performance	Circulation	Respiration
• Speech • Television • Functional capability • Human performance	• ECG* • Pulse rate* • Blood pressure* • Vibrophonocardiogram • Cardiac output • Venous distensibility • Venous occlusion • Ballistocardiogram* • Pulse wave velocity • Plasma volume • Venous pressure and circulation time • Cardiopulmonary symptoms • Capillary fragility • Vascular reflex • Reticulocyte count	• Respiratory rate* • Respiratory depth • Respiratory gases • Inspiratory arteriolar • Vital capacity • Tidal volume • Inspiratory/expertory • Inspiratory capacity • Respiratory quotient • Breath-holding time • End expertory PO_2, pC • Cardiopulmonary symp • Incidence of aerotitis

Metabolism	Fluid Electrolyte Balance And Renal Function	Hematological Response
• Basal metabolism • O_2 consumption* • CO_2 production* • Energy requirements • O_2 dissolved in blood* • Body temperature*	• Kidney-stone formation • Serum and urine potassium and sodium • Tubular reabsorption • Tubular excretion • Urinary albumin • Urine catecholomine • Urine 17KG steroid • Urine urea • Kidney function • Urine pH • Urine protein • Urine sugar • Urine acetone • Occult blood (urine) • Occult blood (feces) • Non protein nitrogen (urine) • Amino nitrogen (urine) • Specific gravity (urine) • Osmolarity (urine)	• Plasma volume • Blood plasma protein • Bleeding time • Red blood cell mass • Serum catecholomine • Serum osmalarity • Blood-urea nitrogen • Red blood cell I_{125} uptak • Red blood cell survival • Clotting time • Serum ATP • Serum 17KG steroid • Prothrombin time • Serum bilirubin • Red blood cell 0_2 uptake • Hemoglobin • Hematocrit • Blood sugar. acetone • White blood count • Red blood count • Differential count • Heme • Hemosidrin • Methamoglobia • Blood cations • Reticulocute count • Blood pH

Table 3-3

TED MEASURES FOR URE MISSIONS

eflex

eserve

oms

Neuromuscular Activity

- Speech
- Lachrymation tests
- Heart size
- Electromechanical delay of heart
- EMG*
- Breath-holding time
- Expertory/inspiratory force
- Heart movement
- Bowel function evaluation
- Cardiopulmonary symptoms
- Voiding evaluation
- Joint motion range
- Muscle fitness
- Muscle size
- Muscle harness

Skeletal Support

- Lean body mass
- Bone demineralization
- Bone density
- Joint motion range
- Total body size

Digestion

- Bowel function evaluation
- G. I. absorption
- Tubular reabsorption
- Tubular excretion
- Voiding evaluation
- Bromsulphalein
- Protein assimilation
- Kidney function
- Occult blood (urine)
- Occult blood (feces)

Central Nervous System And Special Sensory

- Speech
- Inspiratory arteriolar reflex
- EEG*
- Oculometer
- Lachrymation tests
- Vestibular function
- Heart size
- Rheoencephalogram
- GSR/BSR*
- Visual fields evaluation
- Ocular tonometry
- Vision illusion evaluation
- Hearing
- Retinal examination
- EOG*

Environmental

- Temperature
- Relative humidity
- PO_2*
- PCO_2*
- P (Residual gases)
- Atmospheric pressure
- Acceleration profile
- Vibration
- Shock
- Ionizing radiation
- Personnel radiation dose
- Atmospheric circulation
- PH_2O*

*Essential measurements: details in Section II

Section 4
SYNTACTIC DATA COMPRESSION

An important data-system function in space missions is reduction in data volume by means of syntactic data-compression techniques. This section contains quantitative data gathered during the "Study of Spacecraft On-Board Test and Data Processing Techniques" that are relative to syntatic data compression of biological data; also included are the data made available from other studies normal telemetry data and on video data. This section is divided into four subsections. Subsection 401 descrives the data-compression algorithm; subsection 4.2 contains data on biodata compression, subsection 4.3 gives data on compresibility of non-biodata; and subsection 4.5 discusses the results achievable on video data.

4.1 DATA COMPRESSION ALGORITHMS

Descriptions of four syntactic data-compressor operations are presented in this subsection:

- Zero-Order Predictor (ZOP)
- Zero-Order Interpolator (ZOI)
- First-Order Interpolator (FOI)
- Cycle to Cycle

4.1.1 Zero-Order Predictor

In the zero-Order Predictor the compressor predicts that succeeding data samples will equal the magnitude of the last transmitted sample within a prescribed tolerance. If a data sample equals or falls outside the tolerance band, that sample will be transmitted and will replace the previous reference sample in memory for subsequent comparisons. Figure 4-1 illustrates the behavior of the Zero-Order Predictor acting on

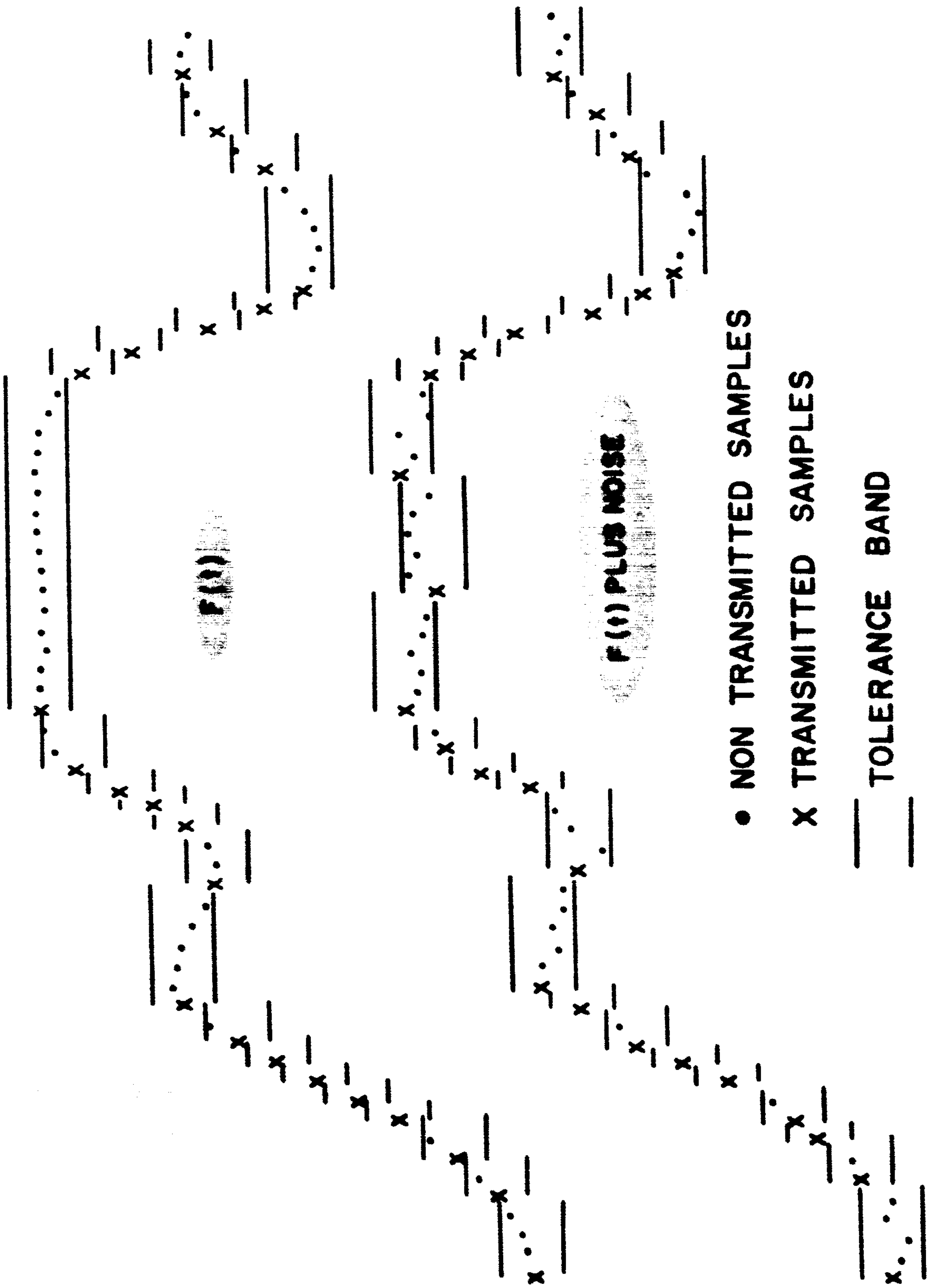


Fig. 4-1 Zero-Order Predictor

a sequence of data points from an arbitrary function. The lower curve, depicting the same process when random noise is added to the time function, shows how low-level noise can affect compression efficiency.

4.1.2 Zero-Order Interpolator

Figure 4-2 shows the performance of the Zero-Order Interpolator. The upper and lower limits are set $\pm$ 2 K units about the initial data sample in a new sequence, where K is the specified peak error. Both limits are modified as a function of data activity such that the difference between a limit and the most recent data sample must be equal to or less than 2 K units. It is important to note that the upper limit is permitted to decrease only; the lower limit to increase only. An out-of-tolerance condition will occur when a new data sample falls outside the tolerance band. Under these conditions, the average between the previous upper and lower limits will be transmitted. This transmitted sample will always be less than K units from each sample within the redundant sequence. The new upper and lower limits are then set $\pm$ 2 K units about the out-of-tolerance point and the process is repeated. The lower curve in Fig. 4-2 shows less susceptibility to noise.

This algorithm is optimum for a zero-order polynomial representation assuming a peak error decision criterion. This statement can be verified by using a straightedge to draw horizontal lines from left to right while staying within K units of each data sample.

4.1.3 First-Order Interpolator

This compression algorithm is similar to the Zero-Order Interpolator except that the upper and lower limits are computed from two straight-line slope predictions as illustrated in Fig. 4-3. These predictions are modified as a function of data behavior. This logic is not optimum in that the starting point of a polynomial segment does not have freedom. The termination point of a line segment is common to the initial point of the following line segment.

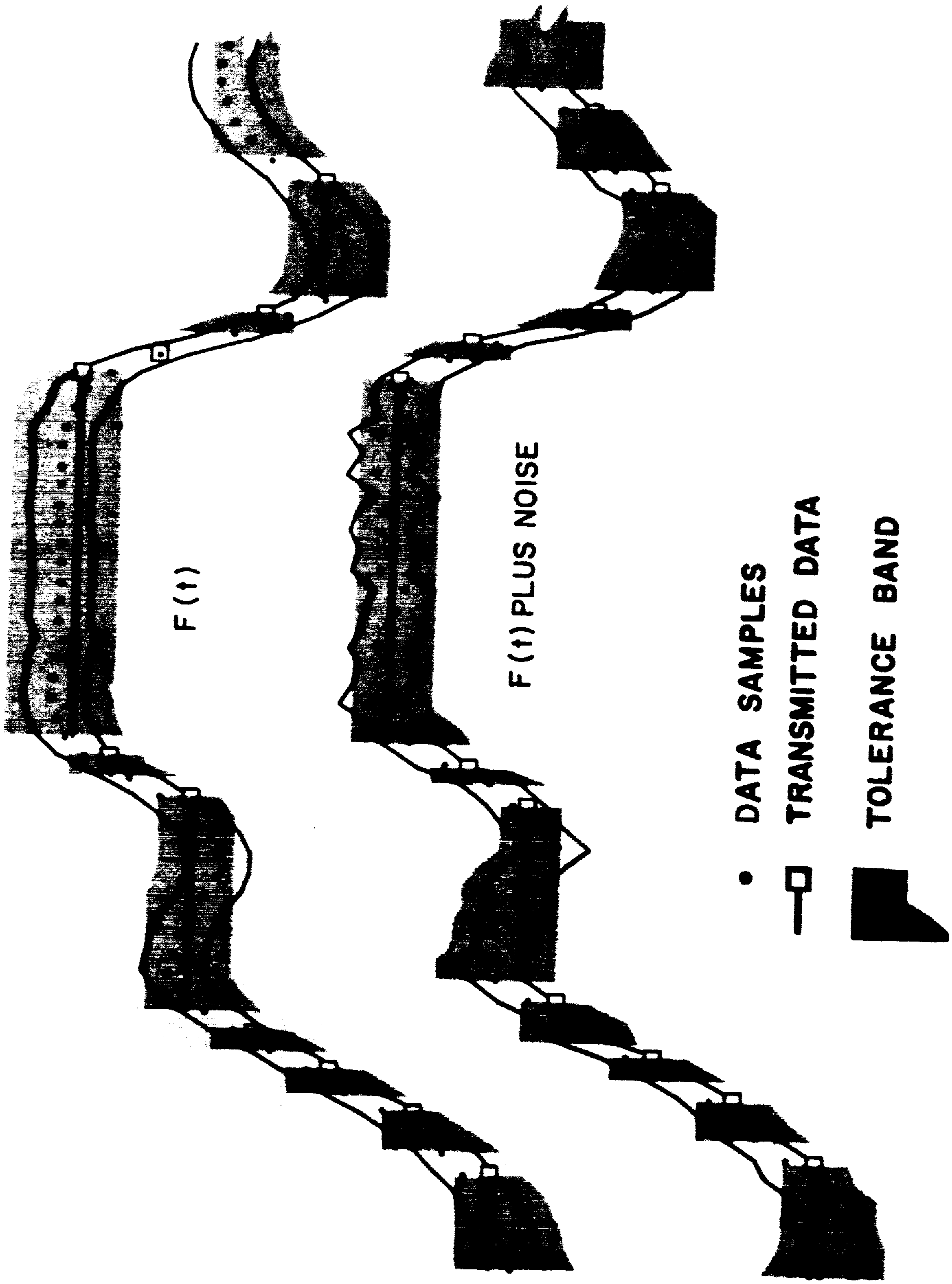


Fig. 4-2 Zero-Order Interpolator

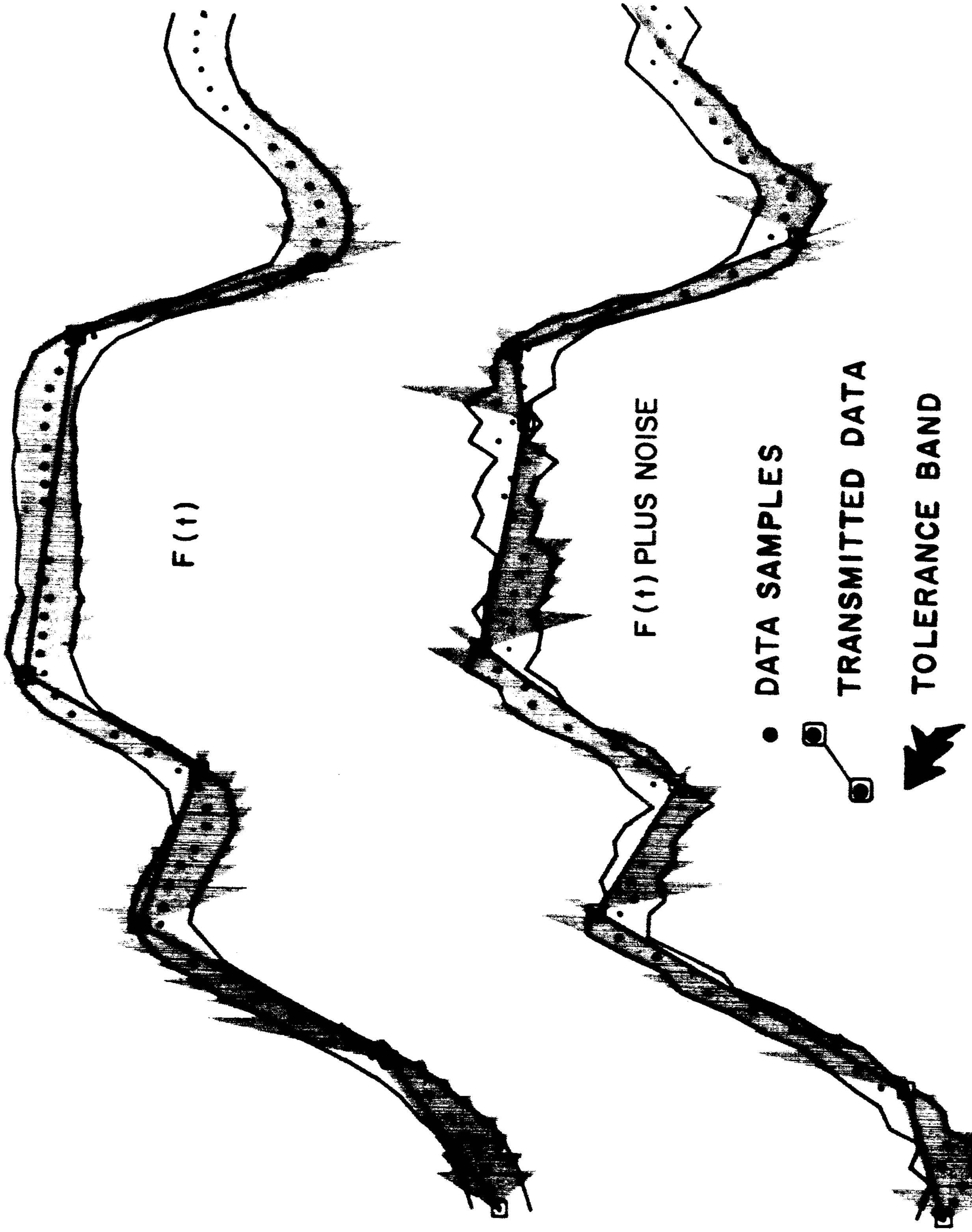


Fig. 4-3 First-Order Interpolator

Investigation has shown that this algorithm has a tendency to oscillate in a manner similar to a bang-bang servo system. This characteristic can be avoided if a new line segment is initialized on the data sample that caused the previous line segment to terminate. This modification has resulted in a considerable increase in word compression ratio and has since been called the "Disjoined First-Order Interpolator." More recent investigations have shown that it is also possible to improve compression efficiency without specifying both ends of the line segment if the initial point of the new segment is specified by an approximation. For the first line segment, the starting point is the first data point. Four different criteria have been used to select the starting point for succeeding line segments. These four methods are described by the name of the resulting compression logic, as follows:

- First-Order Interpolator Disjoined Line Segment (FOIDIS). Uses the out-of-tolerance data point as the starting point for the new line segment. The result is a series of segments disjoint in both time and magnitude.
- First-Order Interpolator Joined Line Segment (FOIJON). Uses the last interpolated point in a line segment as the starting point for the next line segment. The resulting series of line segments are joined together.
- First-Order Interpolator Offset With Direction Determined by the Out-of-Tolerance Condition (FOIOOT). Uses, as the starting point for the next line segment, the last interpolated point in a line segment offset in magnitude by a preselected amount (usually K) in a direction determined by which limit was exceeded.
- First-Order Interpolator Offset With Direction Determined by the Line Slope. Uses, as the starting point for the next line segment, the last interpolated point in a line segment offset in magnitude by a preselected amount (usually K), in a direction determined by the line slope.

4.1.4 Cycle by Cycle

Cycle-by-cycle compression was devised for use on periodic data such as the ECG. Using this algorithm, each sample of a cycle is given a sample number; then each sample of a cycle is compared with the corresponding sample of the last cycle transmitted. To accomplish this, the last cycle transmitted must be stored in the compressor unit. If corresponding samples differ by an amount greater than a preestablished tolerance, the new sample is transmitted and replaces the old one in storage. This method is seen to be a Zero-Order Predictor applied on a per-cycle, rather than a per-sample, basis. When a cycle of a periodic waveform must be transmitted, one of the previously described algorithms is used to reduce the number of samples required.

4.2 BIO-DATA COMPRESSION

Bio-data are usually evaluated subjectively rather than quantitatively. The effectiveness is therefore best illustrated by comparing a plot of compressed reconstructed data with uncompressed data. Such plots are presented here, along with the output rate after compression and the rms error incurred by the use of the algorithm.

4.2.1 ECG

A typical ECG was digitized and placed on magnetic tape. With the aid of an IBM 7094 and Stromberg-Carlson 4020 plotter, data compression of the ECG was simulated. Zero-Order Predictor (ZOP), Zero-Order Interpolator (ZOI), First-Order Interpolator (FOI) and Cycle-by-Cycle (CBC) algorithms were employed. The resulting plots are shown in Figs. 4-4 through 4-7.

The top waveform in each plot is the original waveform sampled at 600 samples per second. Each sample is represented by a dot. Where the data are not changing rapidly, the dots form lines. Where the data change abruptly, the dots are distinct (as in the QRS complex). There are approximately four complete repetitions of the basic waveform.

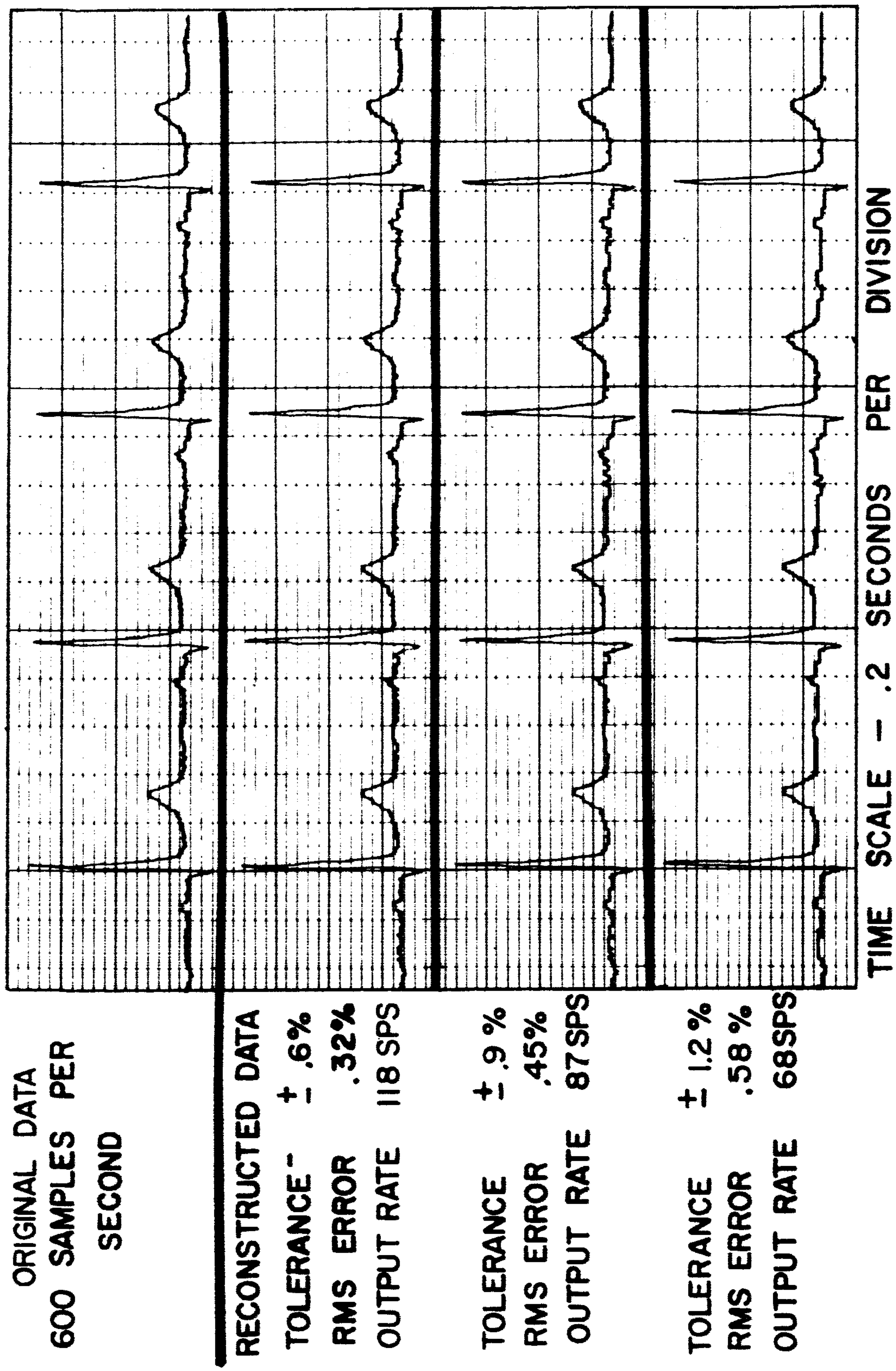


Fig. 4-4 ECG Compressed – Zero-Order Predictor

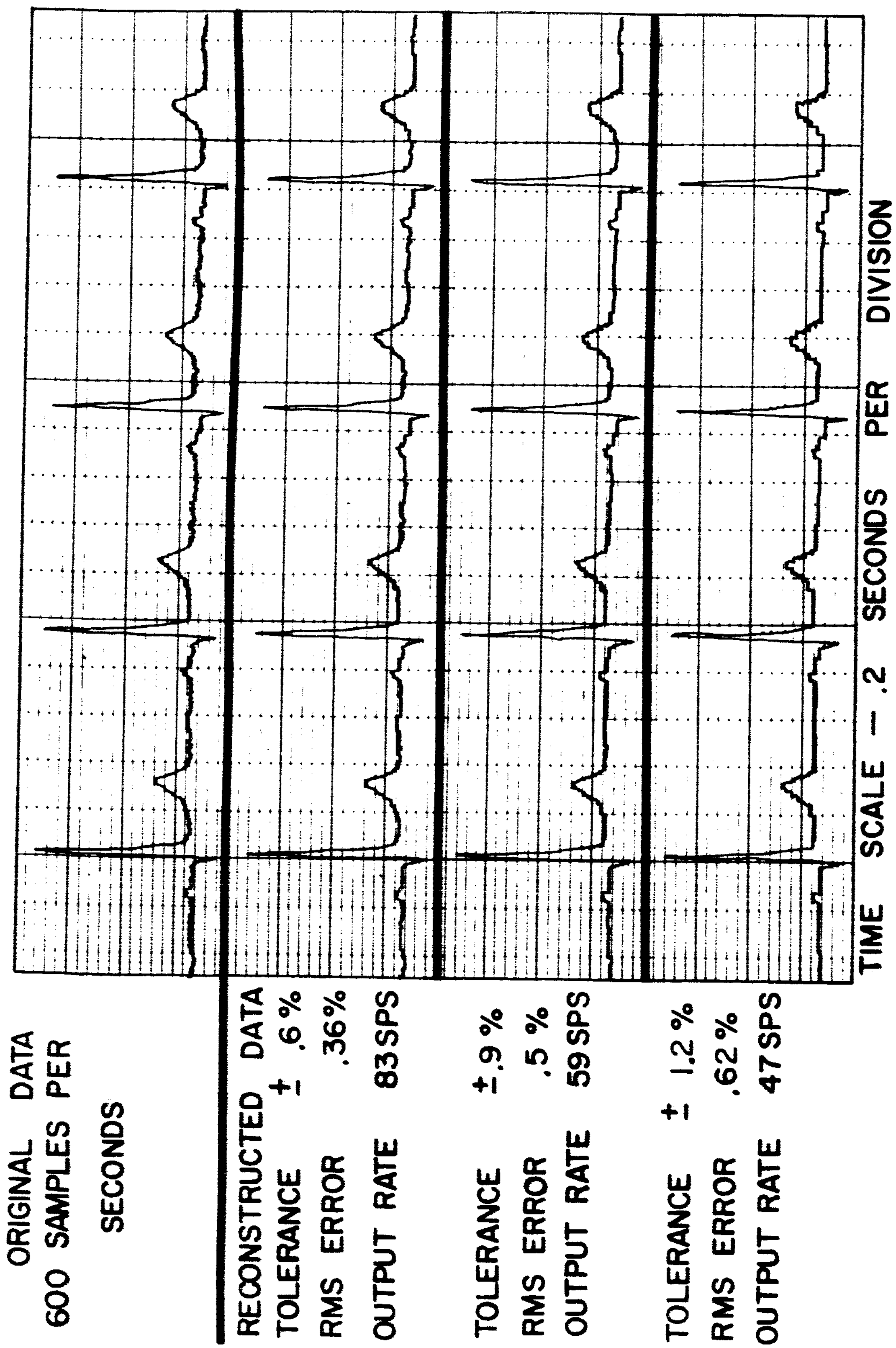


Fig. 4-5 ECG Compressed – Zero-Order Interpolator

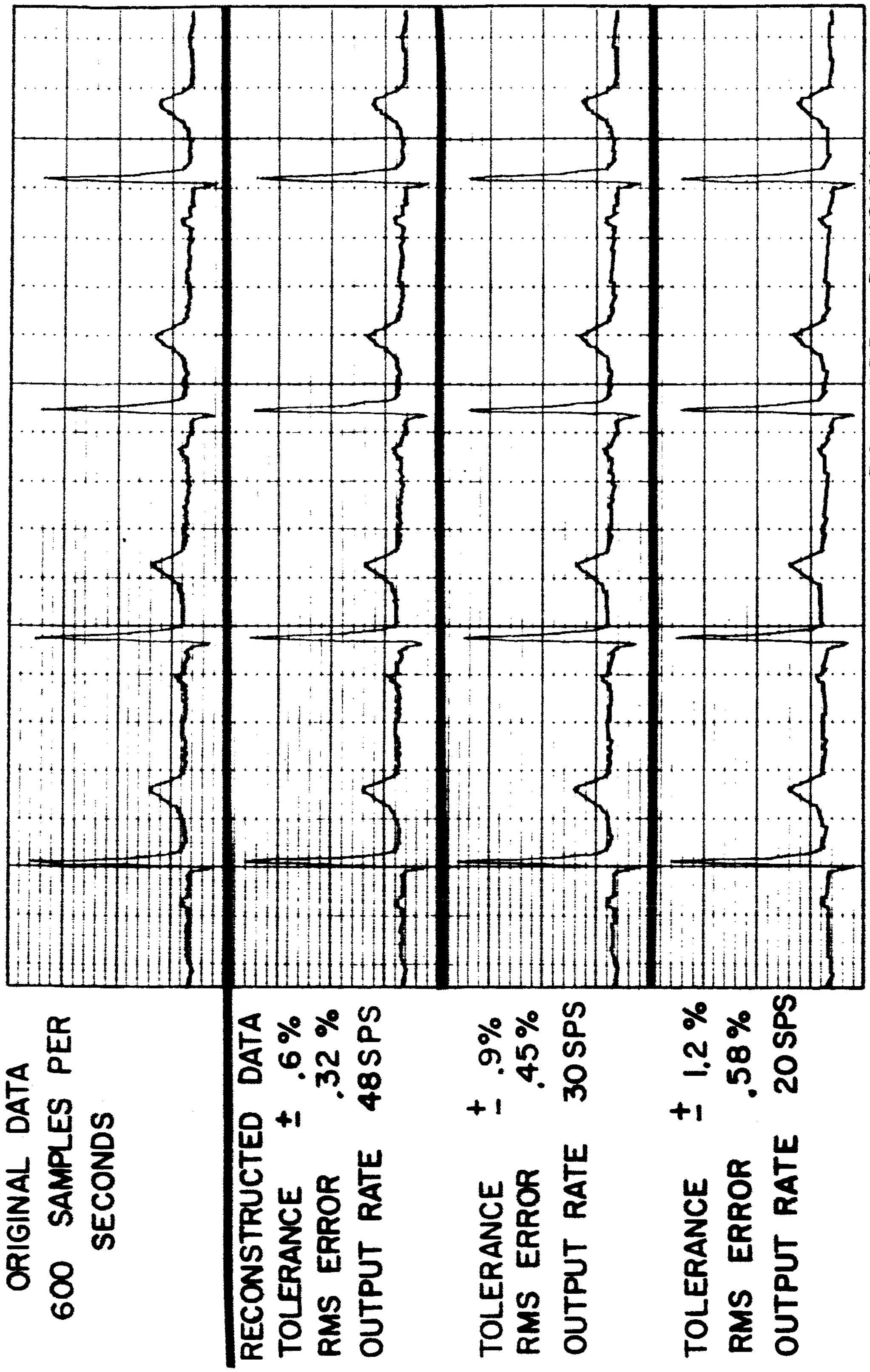


Fig. 4-6 ECG Compressed – First-Order Interpolator

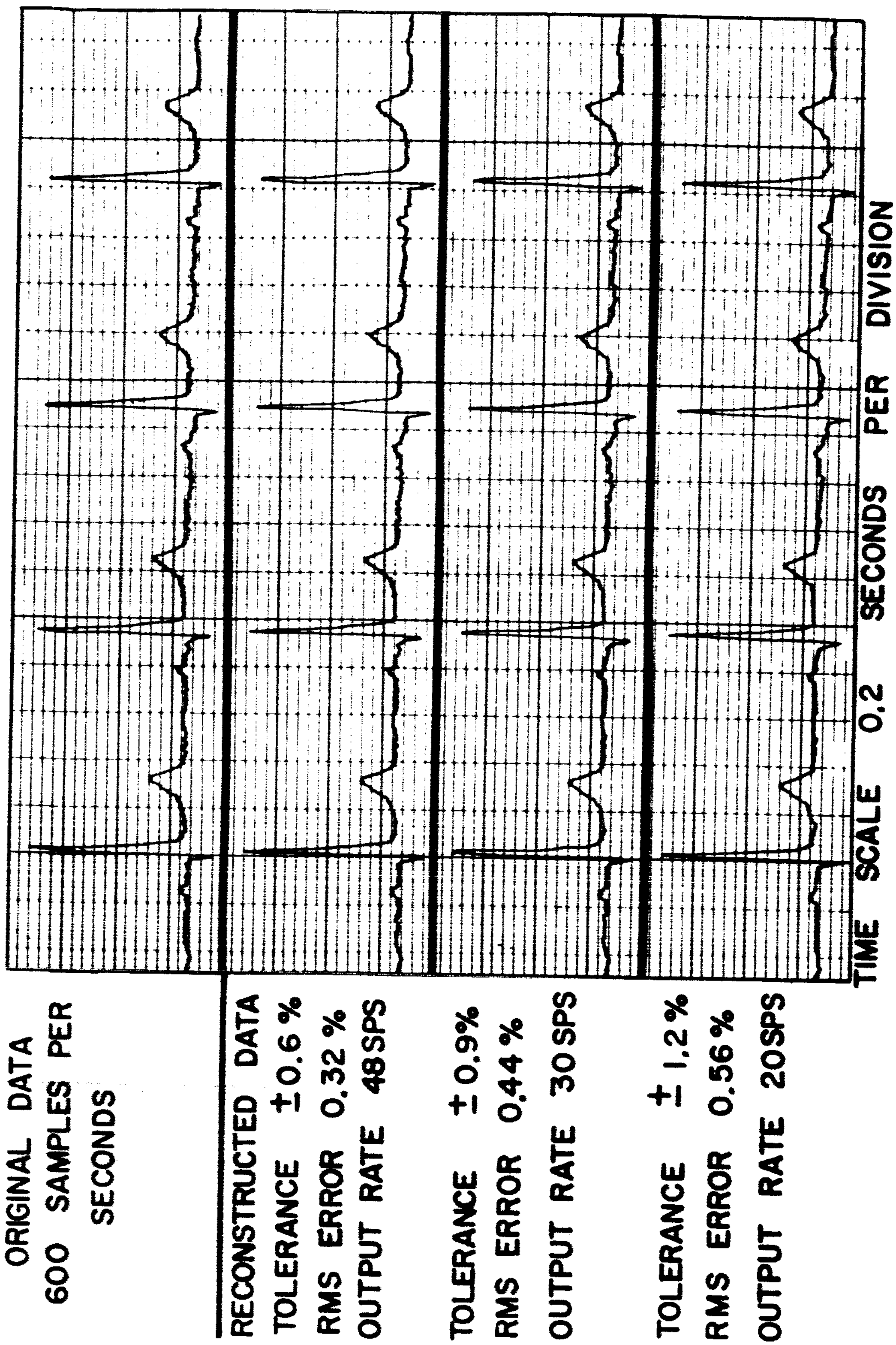


Fig. 4-7 ECG Compressed – By FOI and Smoothed

The next-lower trace represents the reconstruction of the original waveform after compression. The missing samples are reconstructed and plotted within the peak error or tolerance band. The peak error is 0.6 percent of full scale, where full scale is twenty divisions. The time scale is 0.2 sec per division. The next two lower traces represent the reconstructed ECG for increasing peak errors of 0.9 percent and 1.2 percent, respectively.

Figures 4-4 through 4-6 are, respectively ZOP, ZOI, and FOI. Figure 4-7 is the same as 4-6 except that smoothing has been applied after reconstruction.

ECG records from a subject (1) at rest, (2) performing light work, and (3) exercising were used in a computer simulation of the cycle-by-cycle algorithm. ECG signals were digitized on-line under control of a CDC 160 computer. A digital tape was prepared by the CDC 160 that was used as the input tape to an IBM 7094 during simulation runs. The 7094 prepared plot tapes for a Stromberg-Carlson 4020 plotter, and the resulting plots are shown here. As in the previous plots of Figs. 4-4 through 4-7, the upper traces in Figs. 4-8 through 4-10 are the original waveform, and the lower traces are the compressed reconstructed waveforms.

4.2.2 EEG

EEG data were compressed using a computer simulation of a First-Order Interpolator. EEG sampled data tapes were used as input to an IBM 7094. The data were sampled at 214 samples per second, which is sufficient to show the applicability of data compression to this form of data. These data also had a considerable amount of noise, which was filtered with a digital low-pass filter having a corner frequency of 50 cps. Plots of the original data and the reconstructed data are shown in Fig. 4-11.

The bottom traces are the compressed and reconstructed versions of the data for various various values of tolerance or peak error. The tolerance varies from 2 percent to 4 percent of full scale, where full scale is 10 divisions.

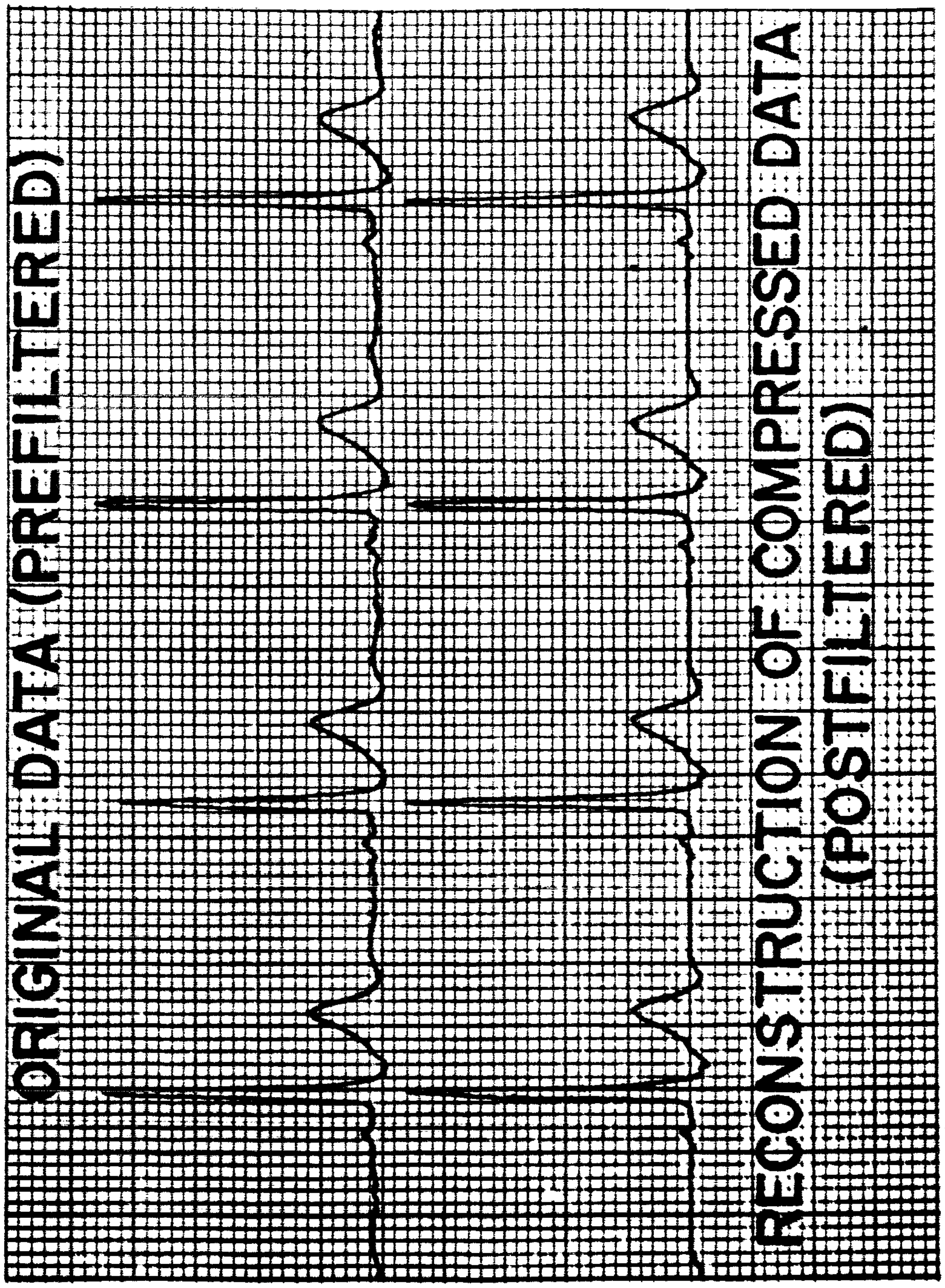


Fig. 4-8 Subject at Rest. Compression Ratio = 1790:1; Tolerance Band ± 14% of Value; ± 1.4% Peak-to-Peak of Waveform

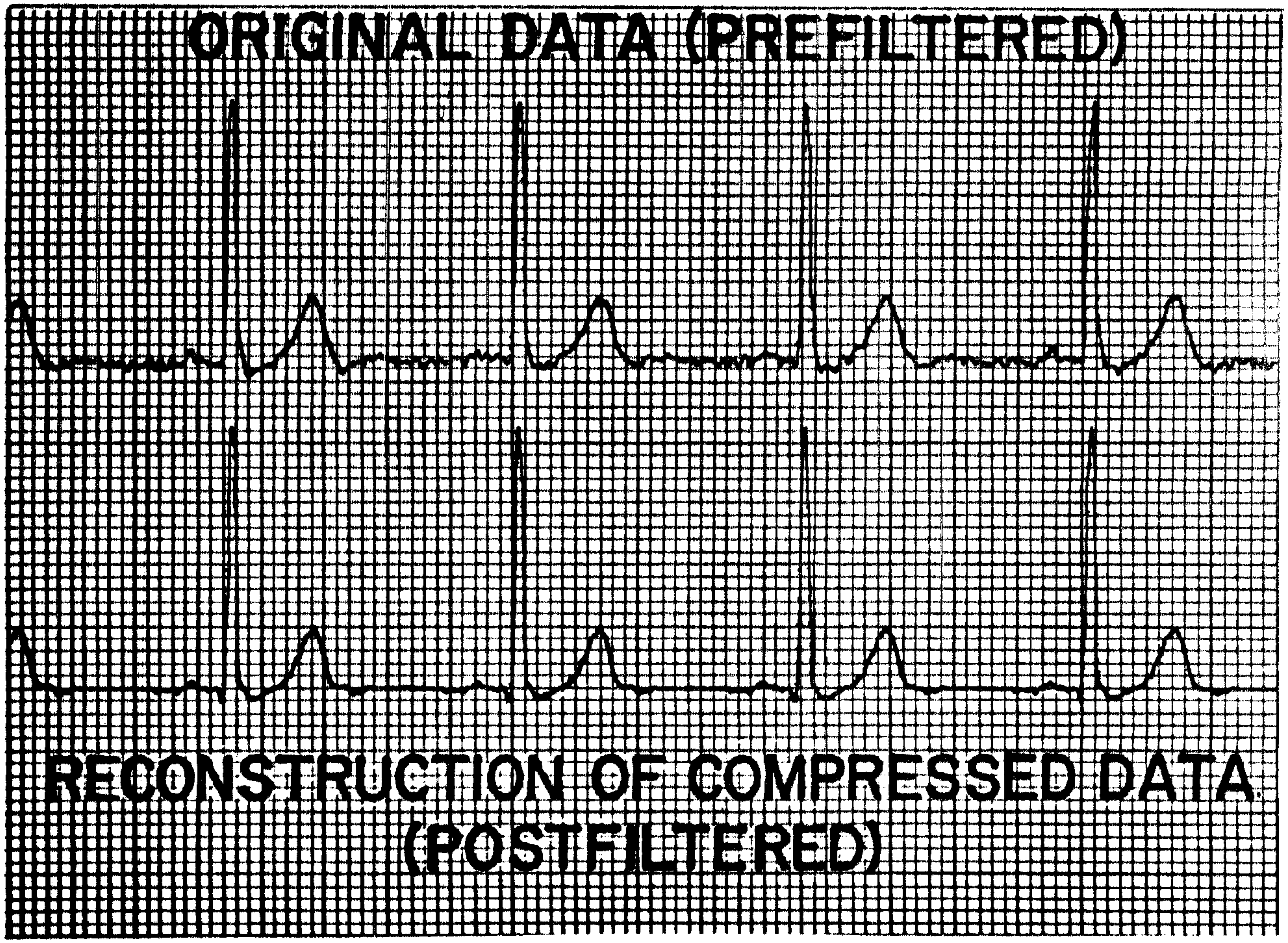


Fig. 4-9 Subject Performing Light Work; Compression Ratio = 274:1

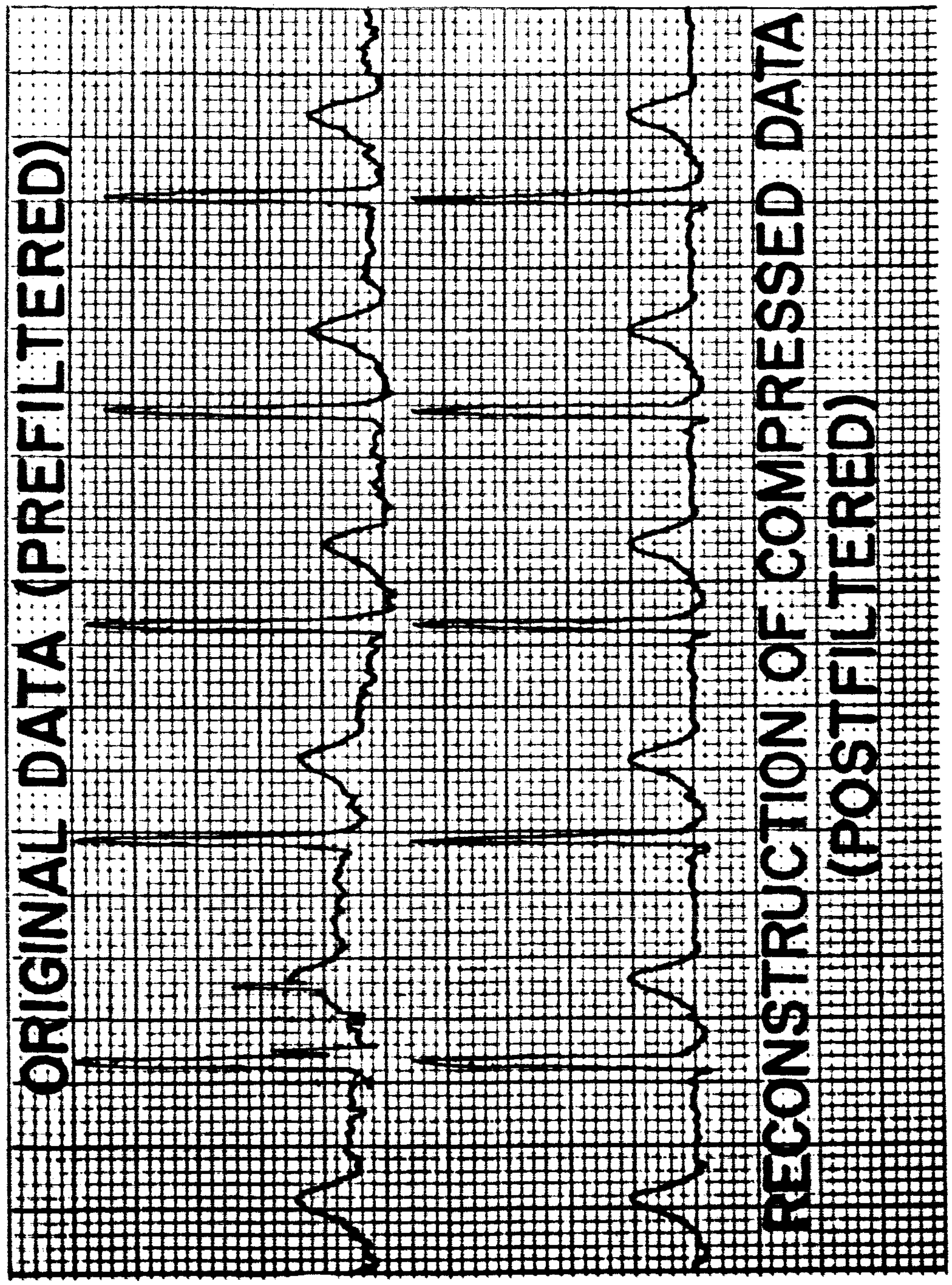


Fig. 4-10 Subject Exercising (Deep Knee Bends). Compression Ratio = 16.2:1

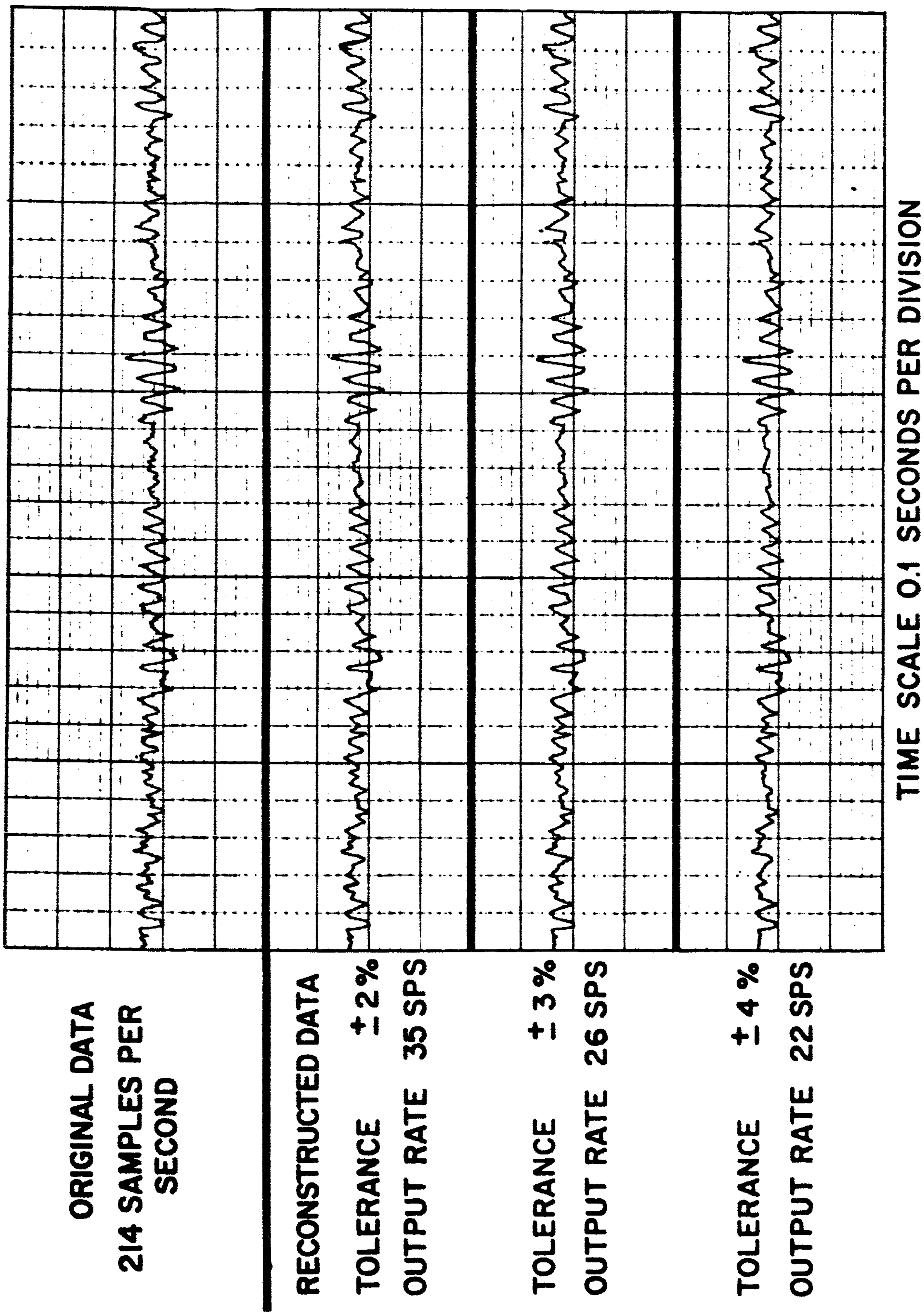


Fig. 4-11 EEG Compressed – First Order Interpolator

4.3 NON-BIODATA COMPRESSION

With the current state of data compression technology, the compressibility of data cannot be determined other than through computer simulation or by extrapolating from known past achievements. To provide some insight into the magnitude of compression ratio that can be achieved on what is usually considered "normal" telemetry data, Fig. 4-12, 4-13, and 4-14 are presented.

Figures 4-12 and 4-13 are plots of the compression ratios achieved on Agena telemetry data consisting of 60 channels of commutated data. Each plot is for a different set of 60 channels. The data used to plot Fig. 4-13 had quite a high noise level. Figure 4-14 is the same type of plot for missile telemetry data. The abciasa on all three plots is the aperture on tolerance used in the compressor selection of data samples; if a sample is within this aperture (which is related by the algorithm rules), the last sample or group of samples is discarded.

These curves may be used to qualitatively assess the compression ratio to be expected for any given mission. To more accurately access the compressibility of any given data set, a computer simulation is required.

4.4 VIDEO DATA COMPRESSION

Video data, as with bio-data, tend to be subjectively evaluated rather than quantitatively evaluated. For this reason, actual reproductions of compressed and reconstructed pictures are presented for comparison with the uncompressed. In addition, plots of achieved compression versus tolerance are included for quantitative interpretation. The photos used in the computer simulation were high-resolution aerial reconnaissance photographs, approximately 178 line pairs per inch. Work currently being conducted indicates higher compression ratios are achievable with lower resolution pictures such as Tiros photographs.

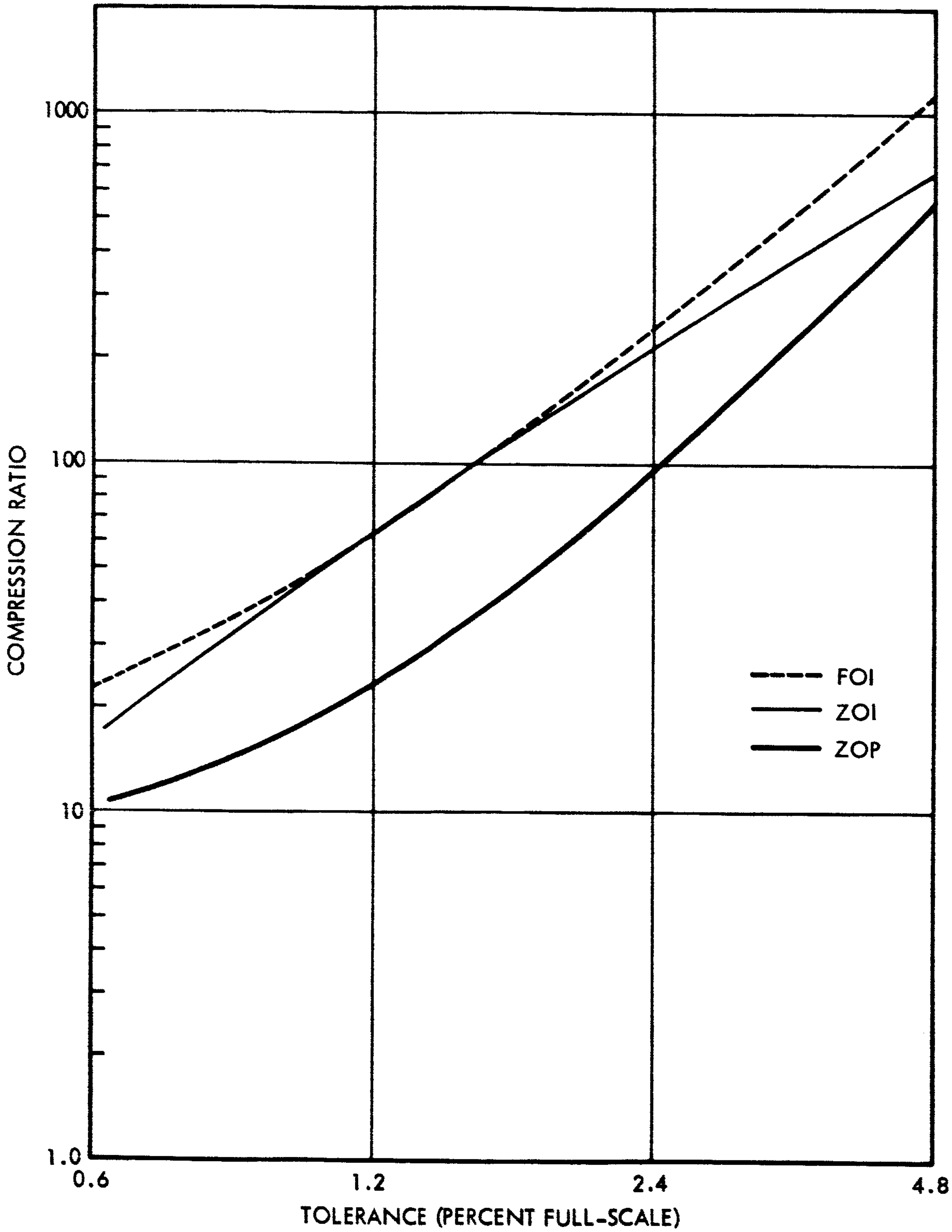


Fig. 4-12 Agena Telemetry Data Set 1

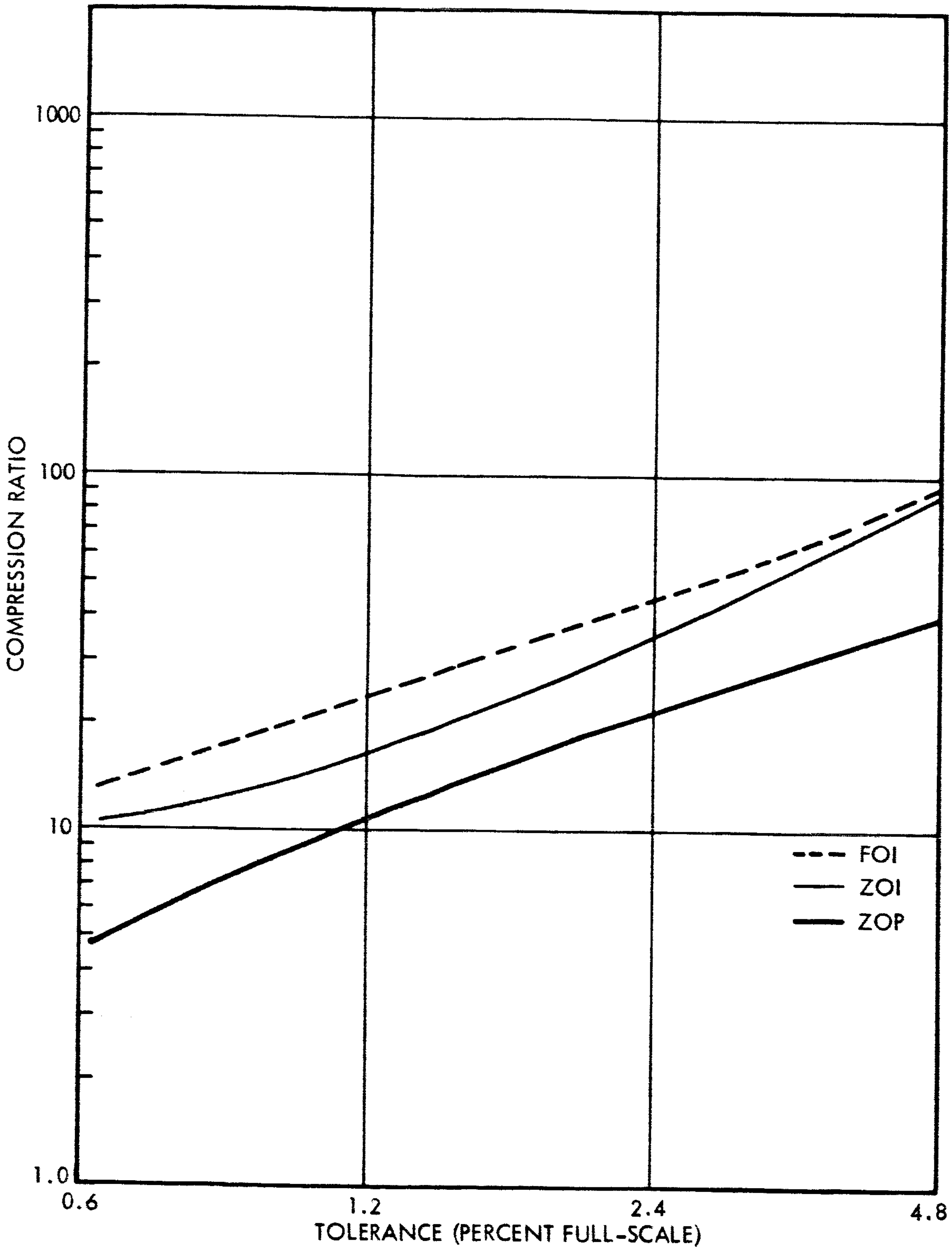


Fig. 4-13 Agena Telemetry Data Set 2

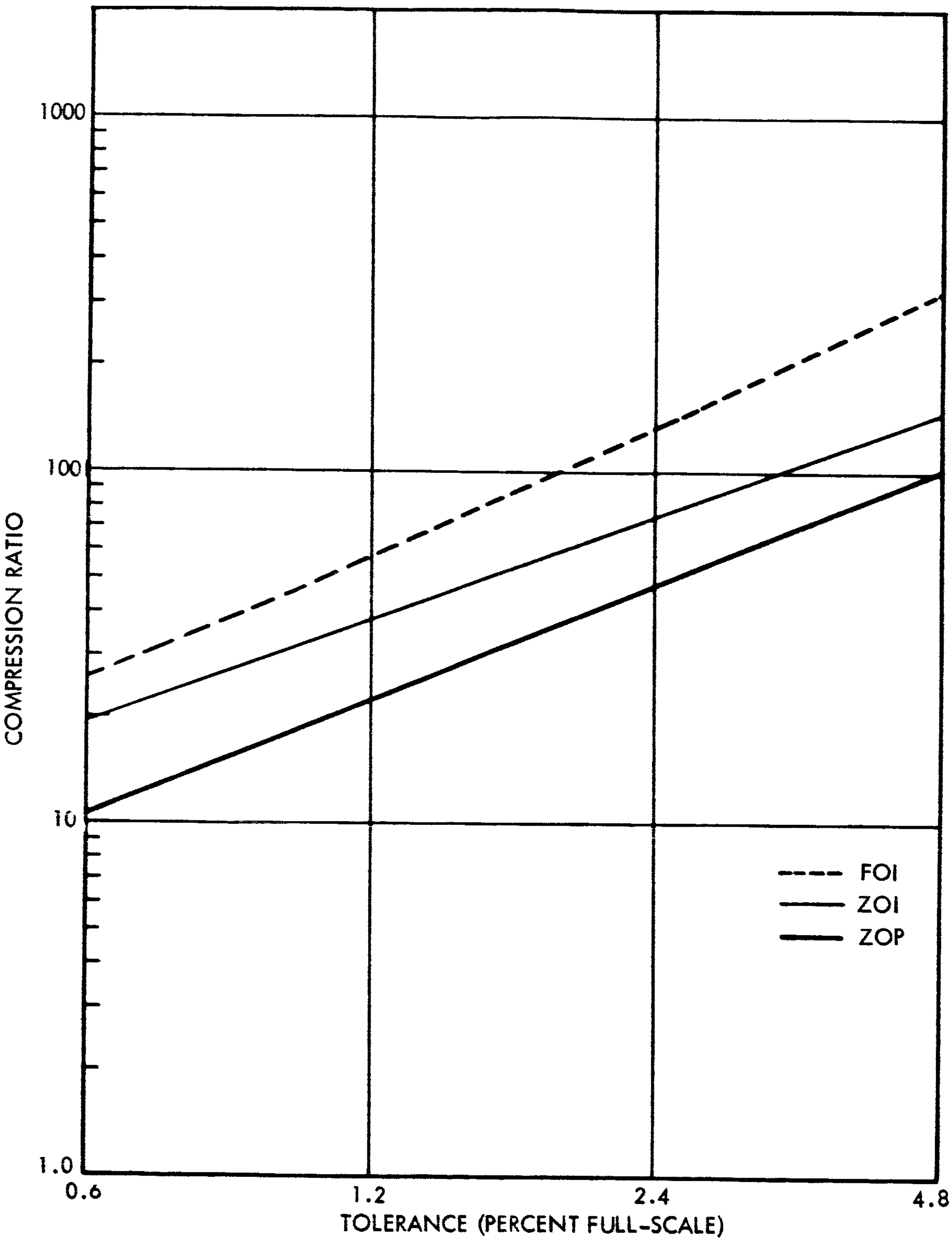


Fig. 4-14 Typical FBM Telemetry Data

Figures 4-15 and 4-16 show the uncompressed photo along with compressed/reconstructed pictures as a function of compression algorithm and tolerance. Figure 4-17 presents a plot of compression ratio versus tolerance for different algorithms. Figure 4-18 displays the reduction in picture transmission time that can be achieved using data compression if the output ratio remains the same as for the uncompressed transmission. This savings can also be reflected in lower bandwidth constant-time relationships. Because the photographs shown in Fig. 4-15 and 4-16 are quite small, Figs. 4-19 and 4-20 are included for comparison purposes. Figure 4-19 constitutes the original 8-1/2 by 11 reconnaissance photographs used in the compression experiment. (The small scanned squares used in Figs. 4-15 and 4-16 are quite apparent in this photo.) Figure 4-20 is the reconstructed photograph after compression.

4.5 REFERENCES FOR SECTION 4

Lockheed Missiles & Space Company, Summary-Advanced Data Compression – 1964, Report 6-62-65-1, by W. Bechtold, L. Bunyon, and P. Drapkin, 1965

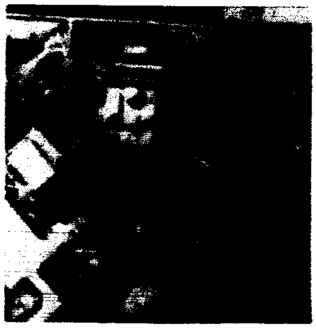
"Sampled Data Prediction for Telemetry Bandwidth Compression," J. E. Medlin, 1964 Wescon, Aug 25 – 28

Lockheed Missiles & Space Company, A Synopsis on Data Compression, Report 5-13-65-6, by D. R. Weber, 1965

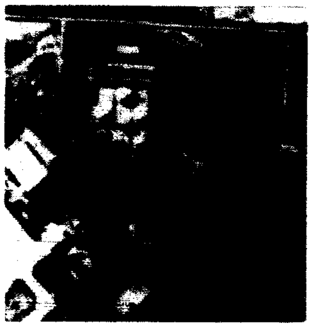
-----, Reconnaissance Photo Experiment, Report 5-65-65-1, by P. Drapkin and D. Weber, 1965

"Tiros Video Data Compression," (Study currently in progress under contract to GSFC, NASA; Contract ends 20 Nov 1965) Data Compression for Polaris," D. Wilcox, LMSC-895376, 18 Sep 1964 Rev. A.

UNCOMPRESSED



K = 1/16
$\bar{N}$ = 11.08

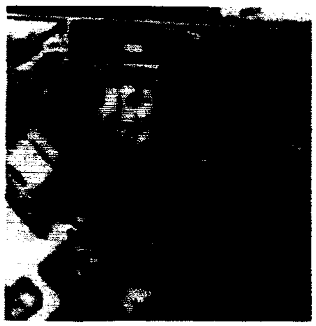


K = 3/64
$\bar{N}$ = 8.48

K = 1/32
$\bar{N}$ = 5.78

FIRST ORDER INTERPOLATOR (DISJOINED)

K = 1/16
$\bar{N}$ = 9.92



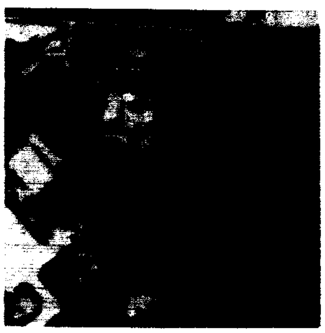
K = 3/64
$\bar{N}$ = 7.40

K = 1/32
$\bar{N}$ = 4.86

FIRST ORDER INTERPOLATOR (OUT OF TOLERANCE)

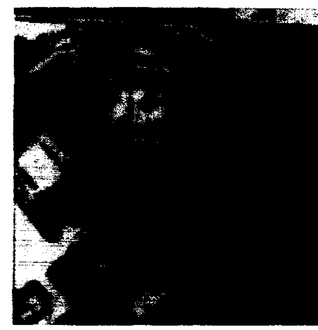
Fig. 4-15 Compression by Zero Order Algorithms. K = Tolerance; N = Element Compression Ratio

UNCOMPRESSED



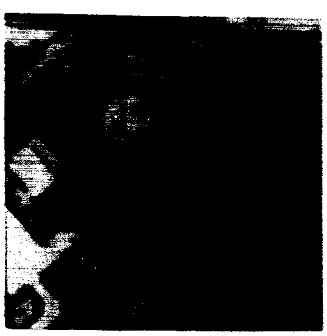
$K = 5/64$
$\bar{N} = 5.86$

$K = 1/16$
$\bar{N} = 4.44$

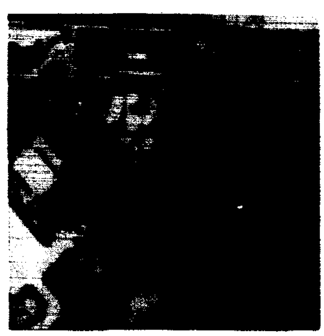


$K = 3/64$
$\bar{N} = 3.14$

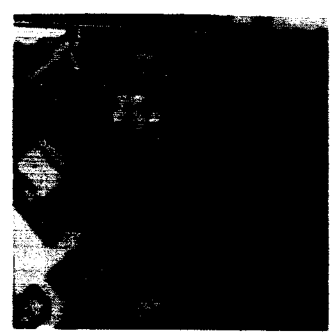
ZERO ORDER PREDICTOR



$K = 5/64$
$\bar{N} = 10.92$



$K = 1/16$
$\bar{N} = 8.27$



$K = 3/64$
$\bar{N} = 5.82$

ZERO ORDER INTERPOLATOR

Fig. 4-16 Compression by First Order Algorithms. K = Tolerance;
$\bar{N}$ = Element Compression Ratio

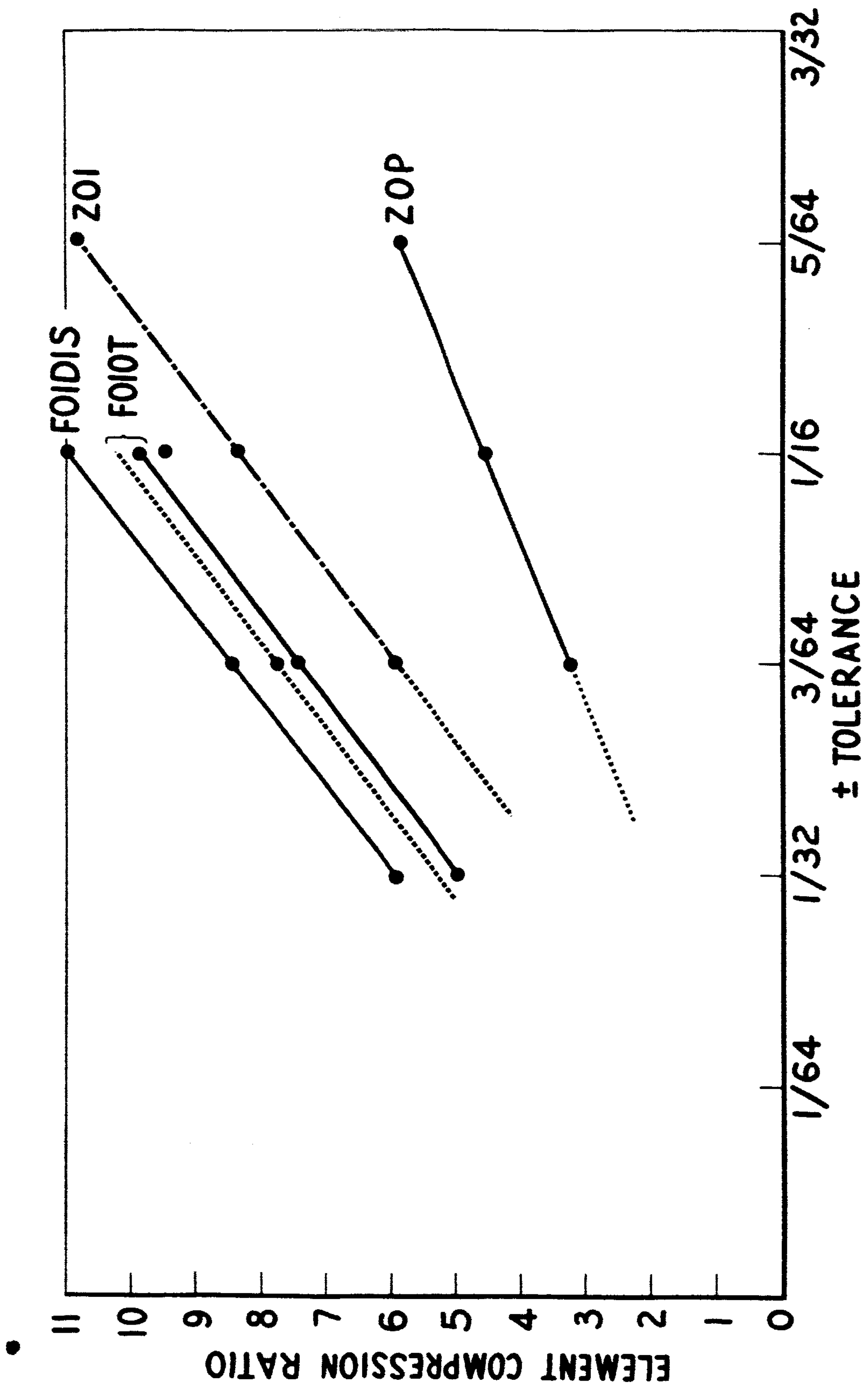


Fig. 4-17 Achievable Video Compressibility

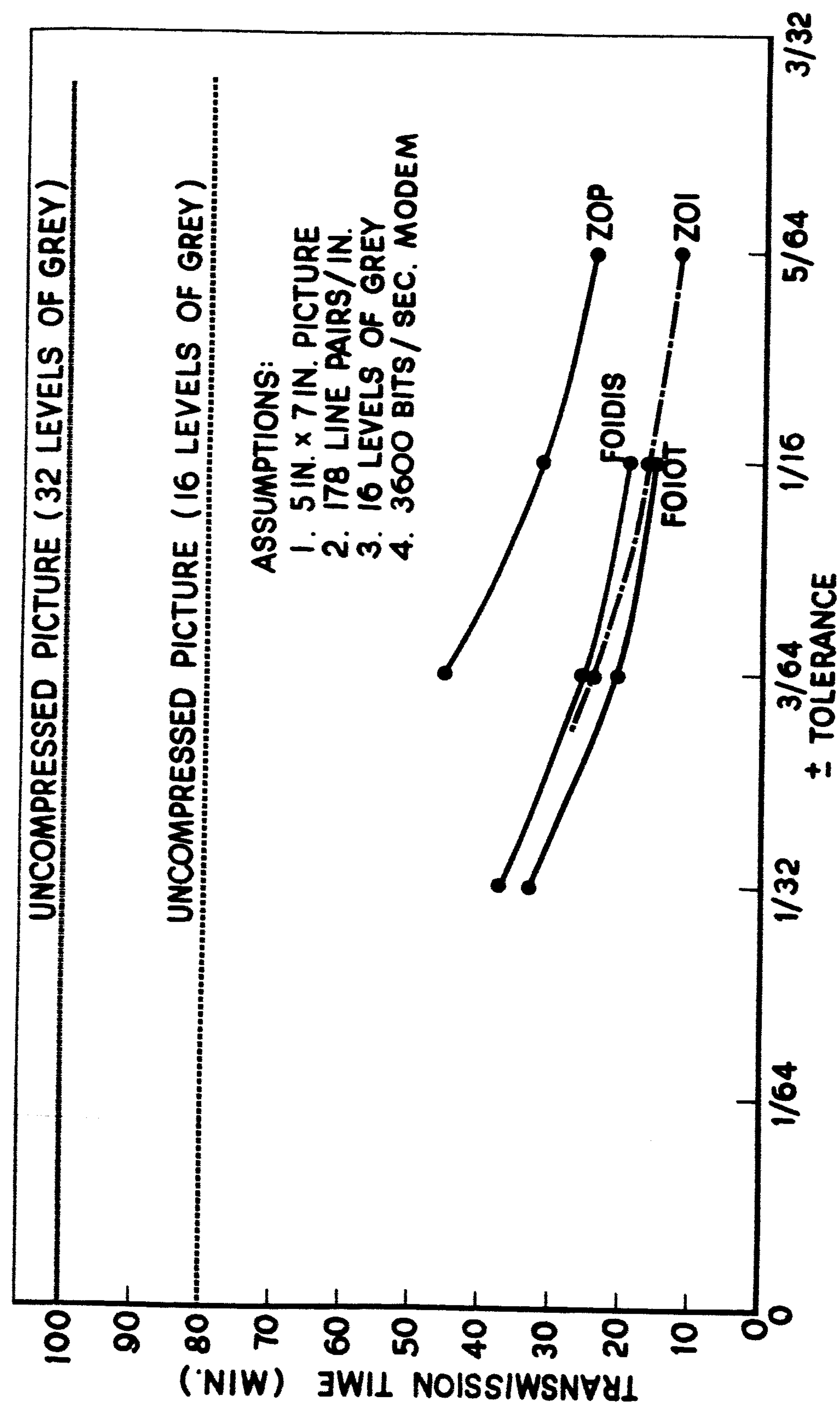


Fig. 4-18 Time Characteristics

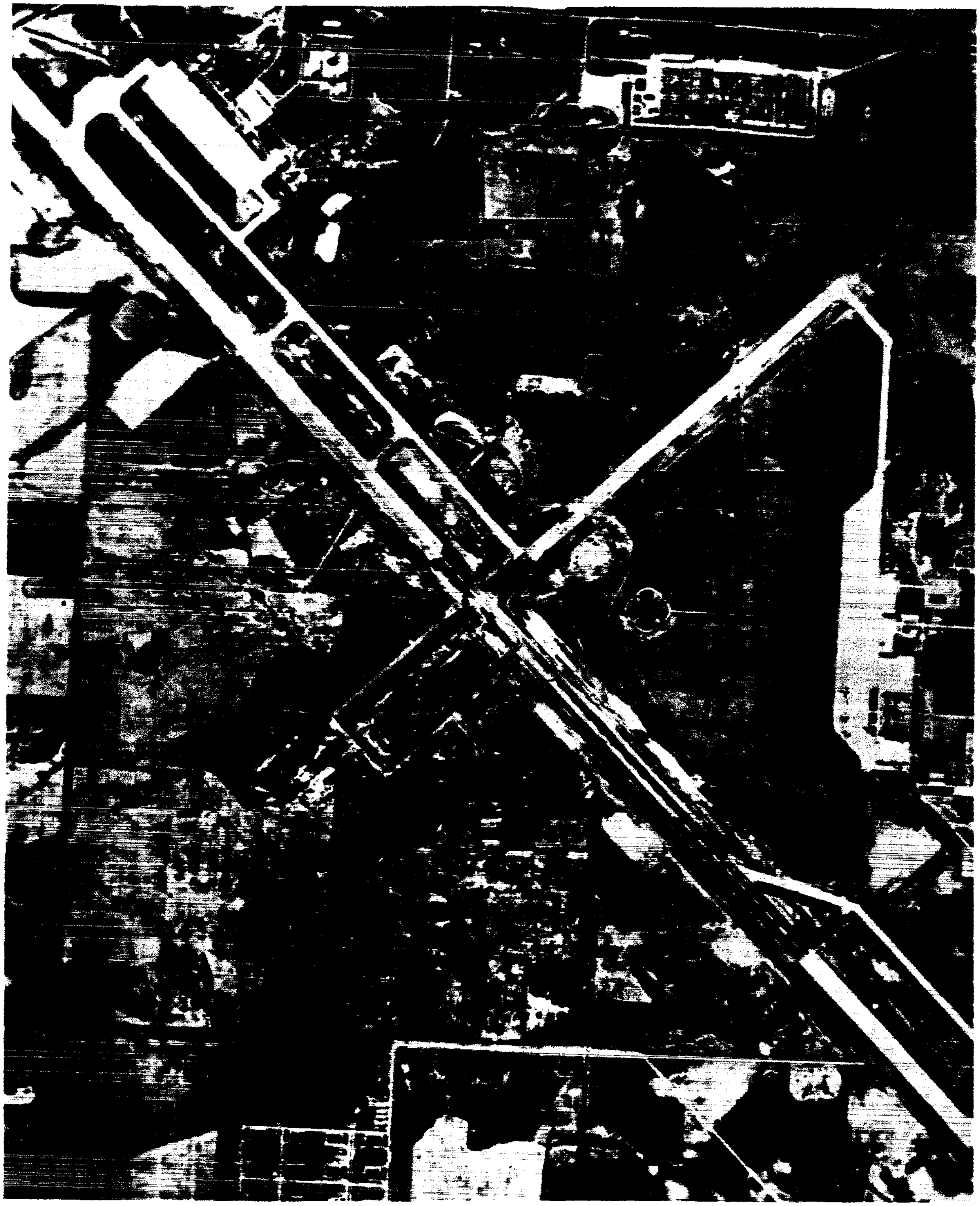


Fig. 4-19 Mosaic (Uncompressed)

Fig. 4-20 Mosaic (Compressed)

Section 5
TELEMETRY SYSTEM CAPABILITIES

Two ground station networks will be used for future manned space flights, the NASA Manned Spaceflight Network (MSN), and the Deep Space Instrumentation Facility (DSIF). The MSN will be used for missions with maximum slant ranges equal to or less than 8,000 nm. Beyond this distance, the DSIF will be used.

5.1 MANNED SPACEFLIGHT NETWORK

5.1.1 Data Transmission

This network is equipped to receive PCM/FM on a 235-Mc carrier. The stations use Nems-Clarke receivers that have a noise figure < 6 db and have antennas with typical gains (at 235 Mc) of 30 db. As in any PCM system, a decision must be made after demodulation as to whether the received hit is a "1" or a "0." The total system noise will cause errors to be made in this decision. Consequently, the system accuracy is a function of the probability of incurring these bit errors. Figure 5-1 is presented as a guide to selection of a signal-to-noise ratio requirement based on the desired probability of bit error. In addition to the curve for PCM/FM of the MSN, Fig. 5-1 contains a curve for the DSIF coherent PCM/PSK. In interpreting Fig. 5-1, select a desired probability of bit error and then determine the required signal-to-noise ratio.

The signal-to-noise ratio, in turn, is related to the telemetry-link parameters as shown in Eqs. (5.1) and (5.2).

$$\frac{S}{N} = \frac{3}{2}\left(\frac{f_d}{f_{LP}}\right)^2 \frac{B_{IF}}{f_{LP}} \left(\frac{C}{N}\right) \tag{5.1}$$

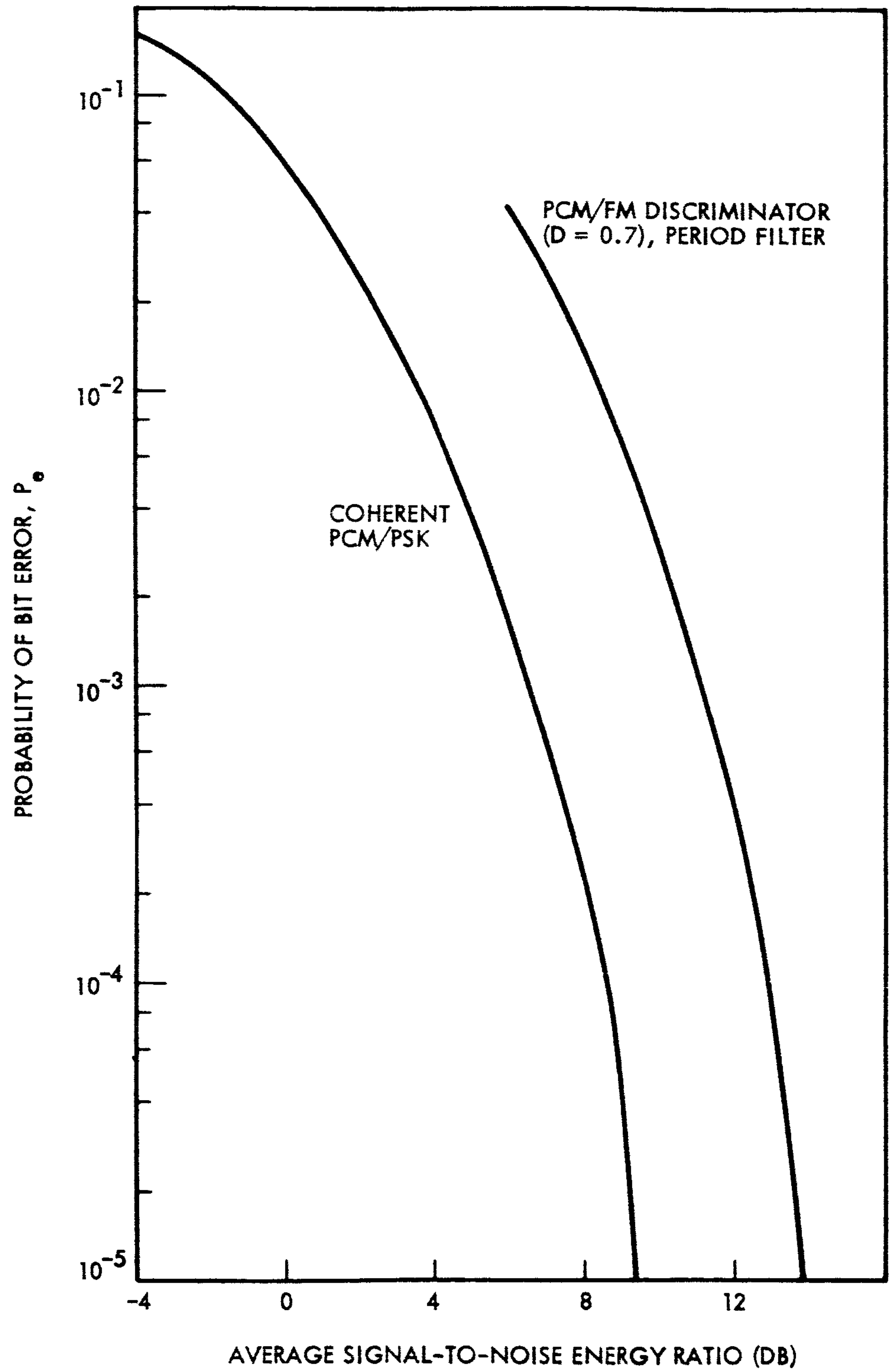


Fig. 5-1 Probability of Bit Error Vs. Signal-to-Noise Ratio

where

$\frac{f_d}{f_{LP}}$ = D = deviation ratio

f_d = maximum frequency deviation

f_{LP} = maximum modulation frequency

B_{IF} = receiver IF bandwidth

C/N = carrier to noise power ratio

and

$$C/N = \frac{G_v \, G_R \, L_e \, L_m}{\left(\frac{4\pi R}{\lambda}\right)^2 k \, (T_A + T_R) \, B_{IF}} P_T \tag{5.2}$$

where

P_T = vehicle transmitter power

G_v = vehicle antenna gain

G_R = ground station antenna gain

L_e = total cable losses on vehicle and ground

λ = wavelength of carrier

R = range in nautical miles

L_m = carrier power last in phase-lock loop

T_A = atmospheric noise temperature

T_R = receiver noise temperature

k = Boltzmann's constant

B_{IF} = receiver IF bandwidth

With the network in question, three of these parameters are variable: P_T, G_v, bandwidth or bit rate, probability of bit error, and range.

Figures 5-2 through 5-4 are plots of these relationships. In all cases, the plots show bit rate versus range for various values of one of the other variable parameters, the other two being held fixed. The variable of Fig. 5-2 is probability of bit error with the antenna gain and transmitter power held fixed at 0 db. Figure 5-2 shows results of variable antenna gain with a $P_e = 10^{-5}$ and $P_T = 1$ watt, while Fig. 5-3 shows various vehicle powers with a 0-db antenna gain and $P_e = 10^{-5}$. For all MSN stations, the maximum data capacity is 1 Megabit, limited only by the receiving equipment. This point is indicated on all curves. Any bit rate resulting from a mission projection that lies above this line must be modified by data compression or elimination of measures in order to match the MSN system.

To use these curves for antenna gains and transmitter power both in excess of 0 db, proceed as follows: choose either the plots of Fig. 5-2 or 5-3 and determine the bit rate from the curve for the appropriate antenna gain or transmitter power. Determine the gain increase in the other parameter in db. The resulting increase in bit rate is

$$b_1 = b_2 \text{ antilog } \frac{db}{10}$$

where

b_1 = increased bit rate

b_2 = bit rate selected from curve

db = gain increase in parameter not plotted on curve selected

5.1.2 Television Transmission

For the MSN, television may be transmitted in either of three modes: PCM/FM, analog FM, or analog SSB. If PCM/FM is used, the curves of Figs. 5-1 through

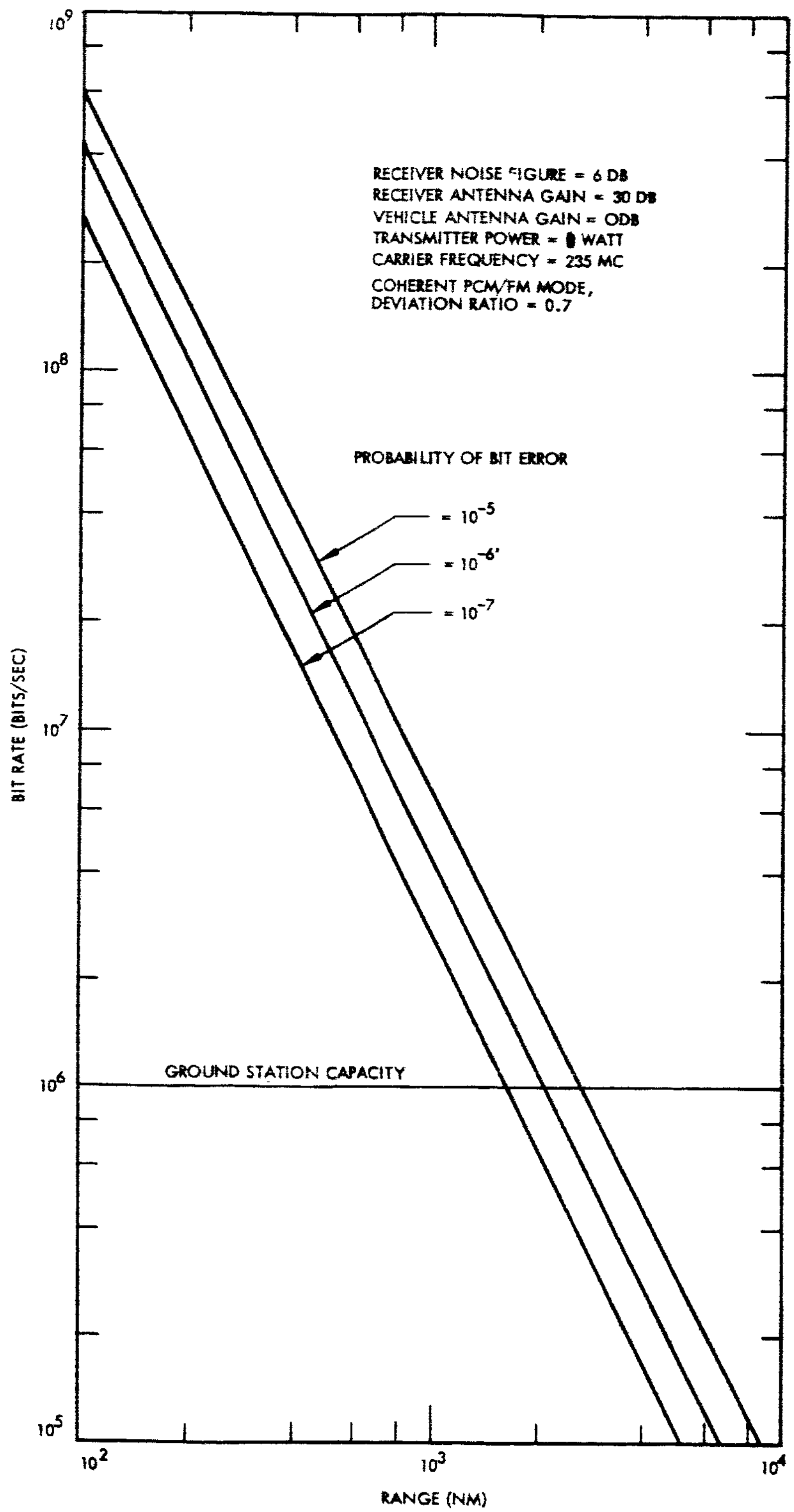


Fig. 5-2 Bit Rate Vs. Range for Different Probabilities of Error for Manned Spaceflight Network

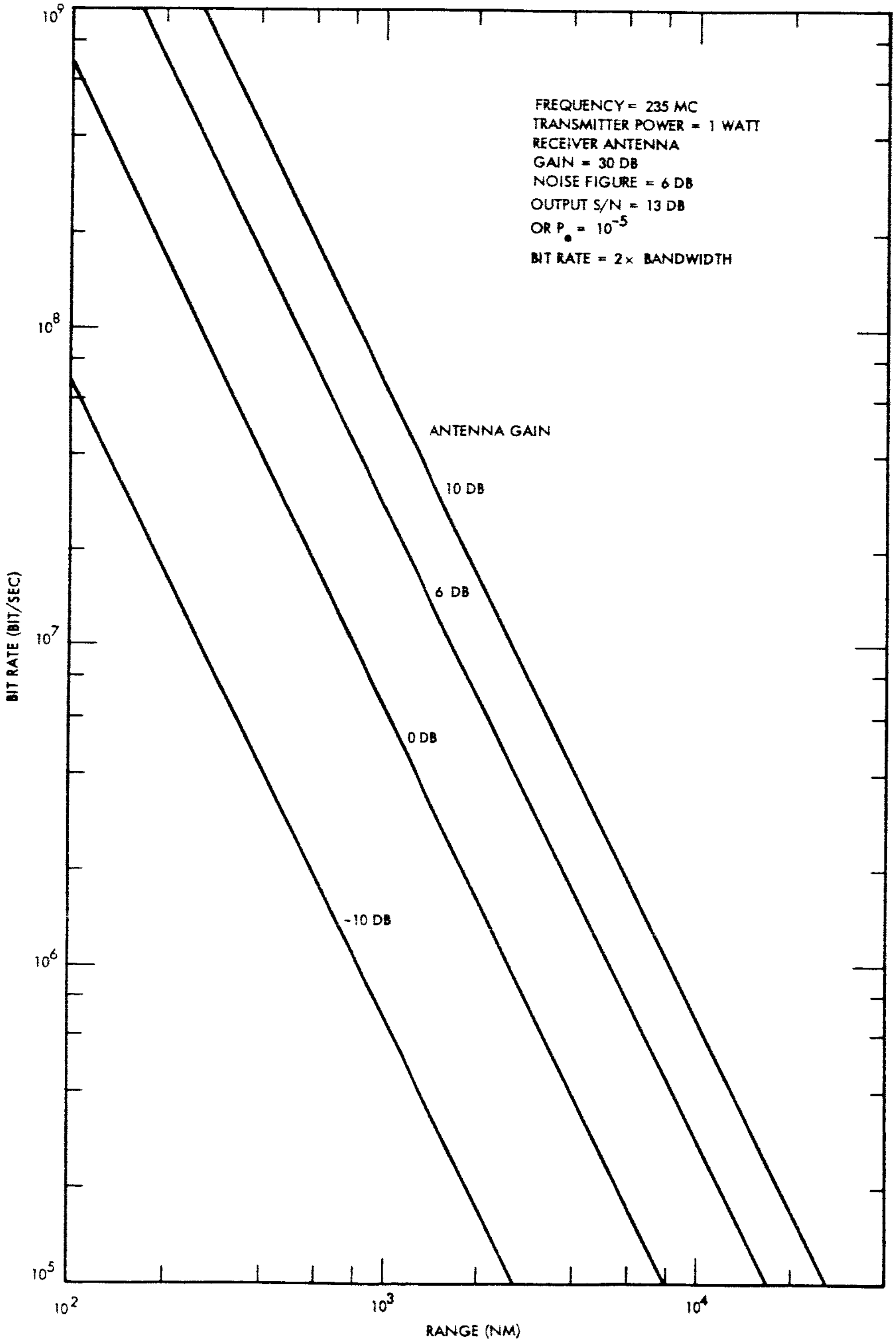


Fig. 5-3 Bandwidth Vs. Range for Various Vehicle Antenna Gains

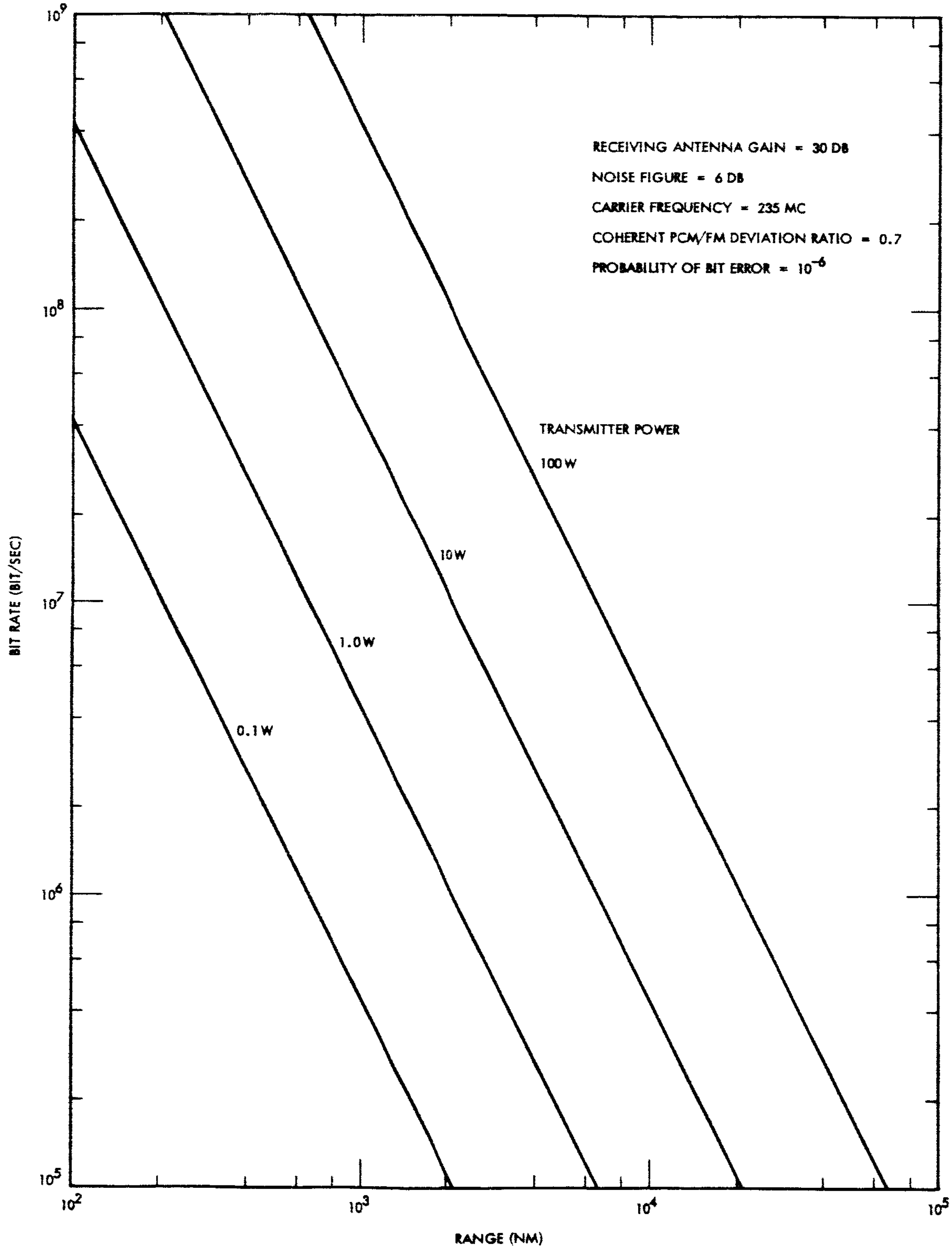


Fig. 5-4 Bit Rate Vs. Range for Different Transmitter Powers for Near-Earth Ground Stations

5-4 apply directly. If the television signals directly frequency-modulate the 235-Mc carrier, the deviation ratio to be used in Eq. (5-1) should be 4, and the modulation loss 8 db. The output S/N is then given directly by Eq. (5-1). With the carrier-to-noise ratio derived from Eq. (5.2), the curves shown in Fig. 5-5 were plotted for the two permissible MSN video bandwidths of 400 kc and 4 Mc. The accepted S/N for a quality picture is 26 db, and this is the quality that is being requested by medical experimenters. This value is indicated in Fig. 5-5.

5.1.3 Voice Communications

Voice transmission in the MSN is accomplished simultaneously on two amplitude-modulated carriers, one at 15 Mc and the other at 297 Mc. The high-frequency link is for line-of-sight communications, while the lower frequency link utilizes ionospheric bounce for non-line-of-sight communications. The intelligibility or quality of voice communications is a direct function of the receiver output S/N and should be 15 db or greater. The receiver used in the MSN ground stations is made by Collins Radio Company. Its operating characteristics, along with a plot of S/N versus range, are shown in Fig. 5-6. On this curve is indicated the 15-db quality level position.

5.2 DSIF TELEMETRY SYSTEM

5.2.1 Data Transmission

The DSIF is a network of seven ground stations around the world providing continuous coverage for deep-space missions. Data are transmitted on a 2.3-Gc main carrier, on which several subcarriers may be multiplexed. The modulation format is PCM/PSK/PM. The DSIF ground stations will have a 210-ft parabolic antenna with a gain of 53 db, and a noiseless, cooled-maser preamplifier with a noise temperature of $55 \pm 10°K$. The probability of bit error versus S/N is shown in Fig. 5-1. The use of this curve has already been explained in subsection 5.1.1. The remaining figures in this section were derived using Eqs. (5.1) and (5.2) with the proper DSIF parameters. Figures 5-7 through 5-9 are the equivalents of Figs. 5-2 through 5-4 for the MSN and are used in an identical manner.

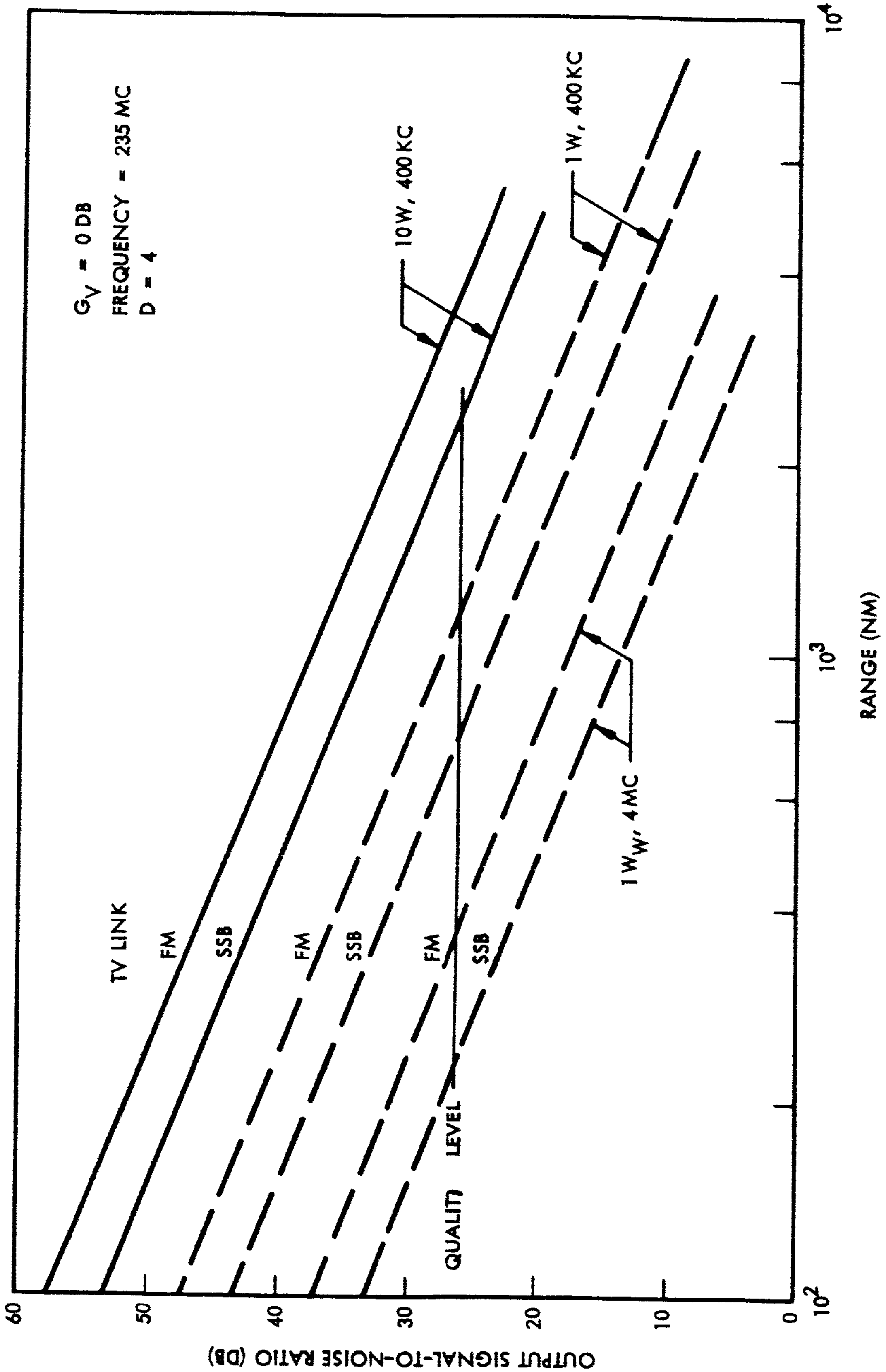


Fig. 5-5 Signal-to-Noise-Ratios for FM and SSB TV Links Near Earth

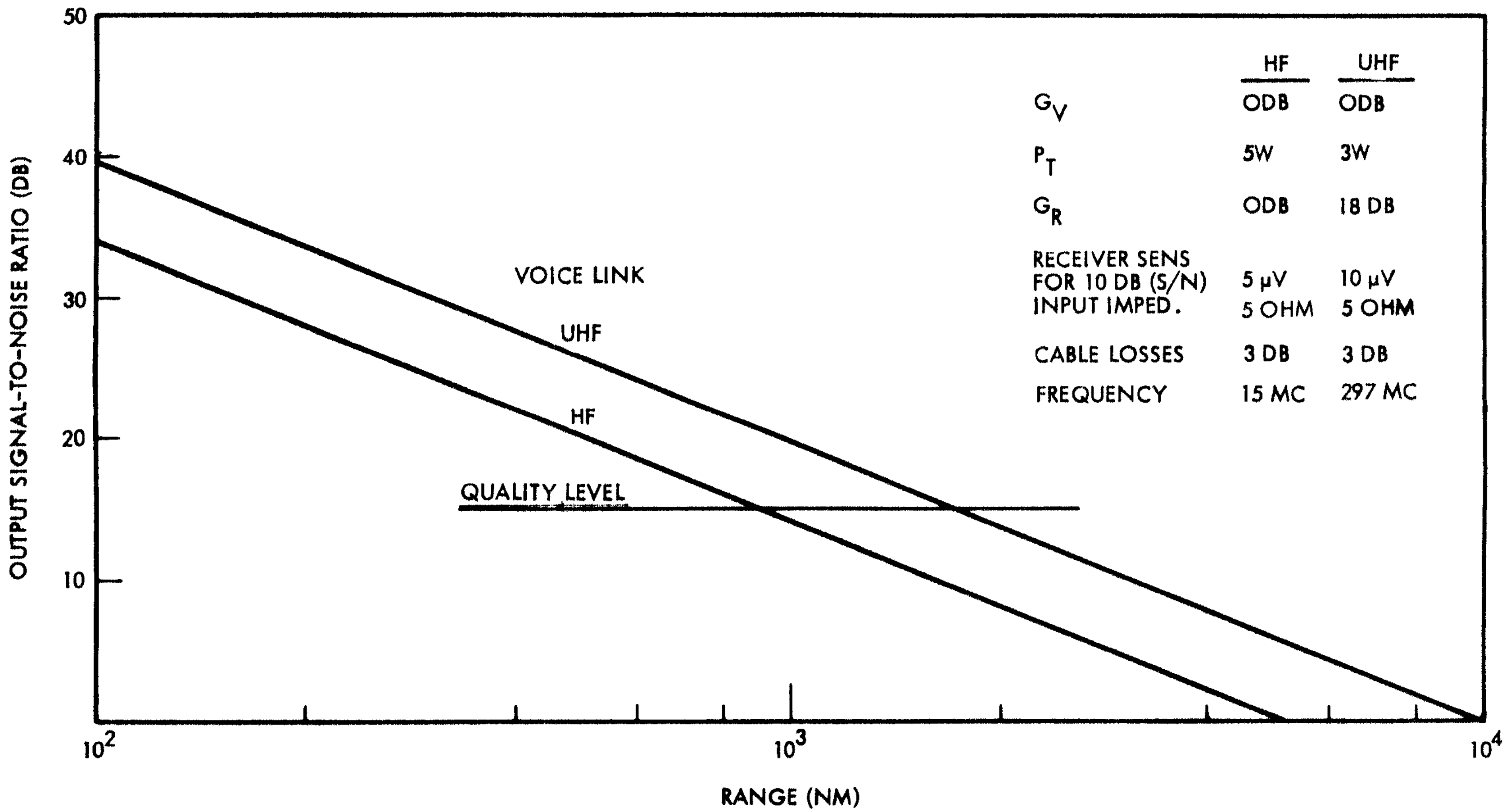


Fig. 5-6 Signal-to-Noise Ratio for Near-Earth Voice Links

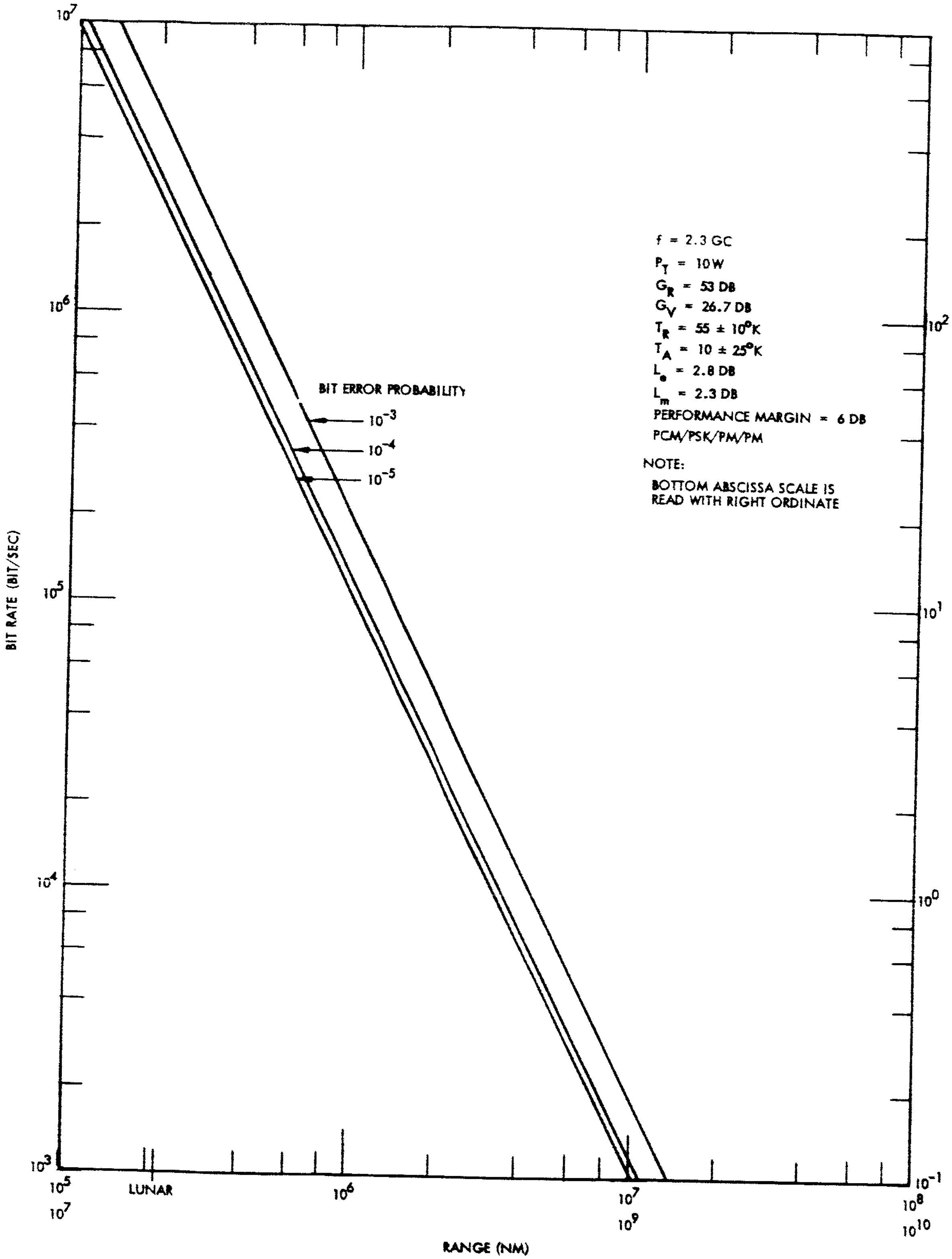


Fig. 5-7 Bit Rate Vs. Range for Different Bit Error Probabilities for DSIF

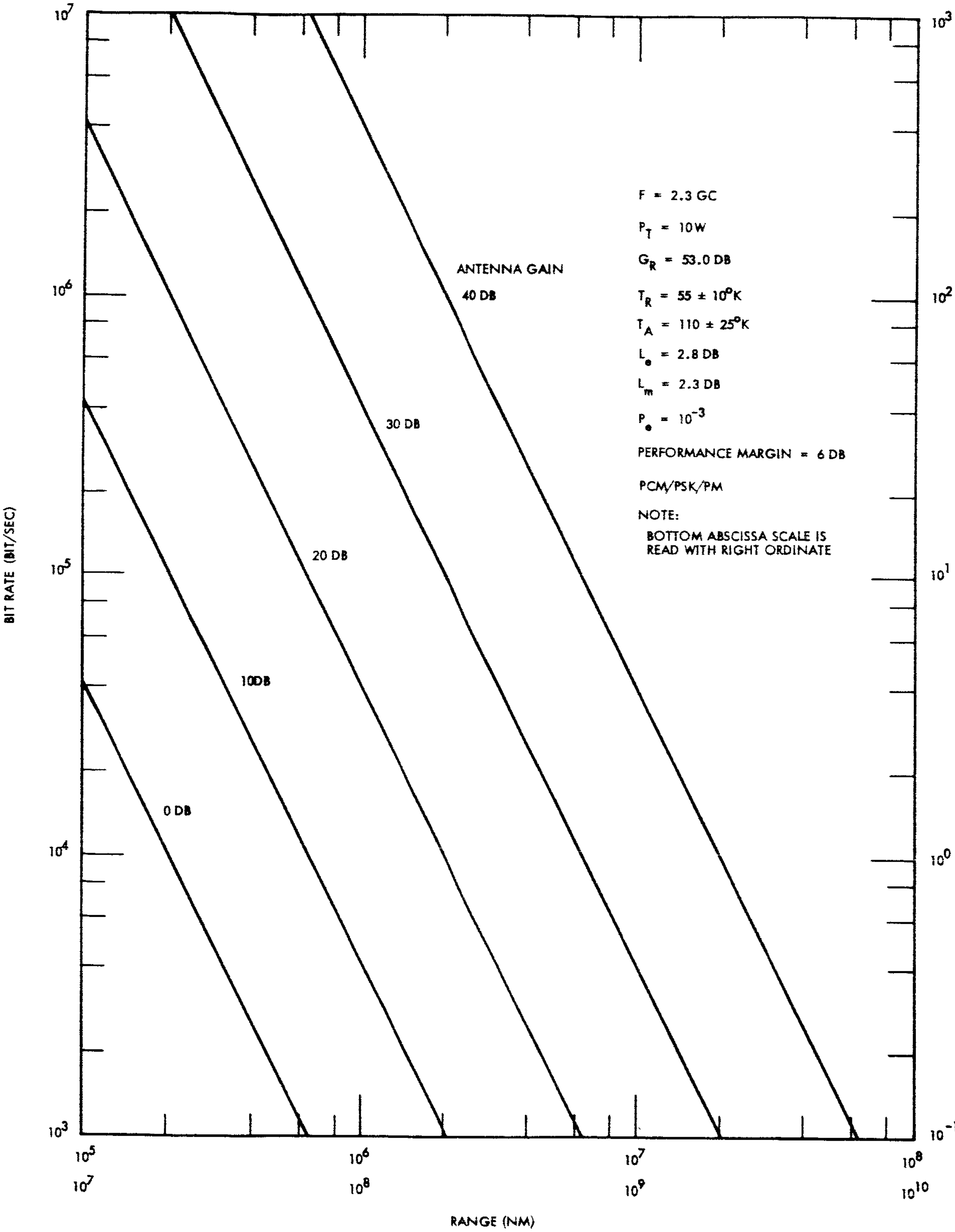


Fig. 5-8 Bit Rate Vs. Range for Different Vehicle Antenna Gains

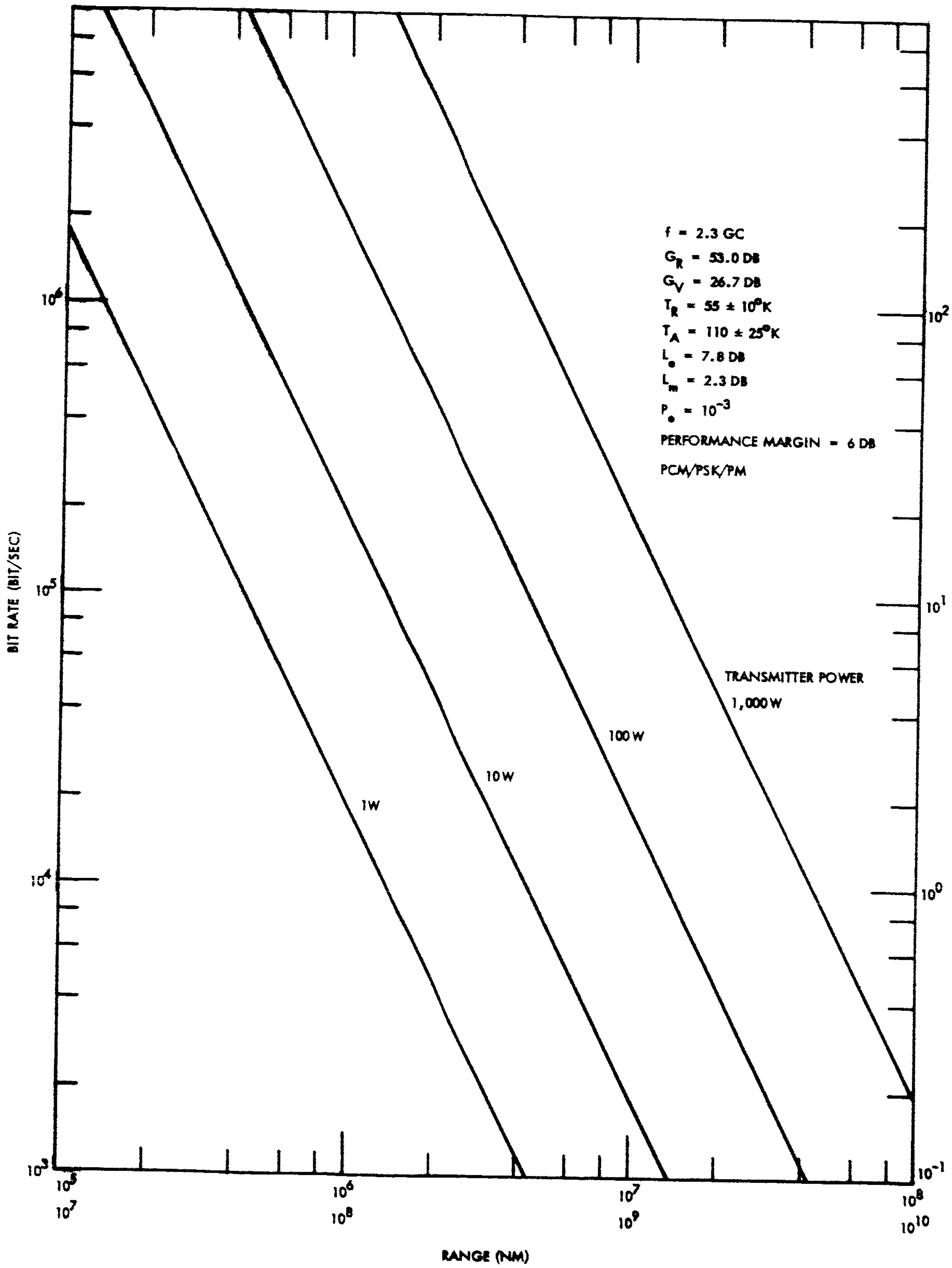


Fig. 5-9 Bit Rate Vs. Range for Different Transmitter Powers for DSIF

5.2.2 Television Transmission

The television signals can be sent by digital mode (PSK/PM), analog frequency modulation (FM), or single-sideband amplitude modulation (SSB). Phase modulation may be used on the main carrier. The digital phase-shift hexing mode has already been described and the bit rates shown in Figs. 5-7, 5-8, and 5-9. The signal-to-noise ratio for the output picture is plotted against range for both FM and SSB in Fig. 5-10 for a transmitter power of 10 w and antenna gain of 26.7 db. The maximum ranges for the 26 db needed for quality picture are 270,000 nm for FM and 130,000 nm for SSB.

The signal-to-noise ratios used in Fig. 5-10 were determined from:

$$(S/N)_{PM} = \frac{1}{2} \Theta^2_{max} \frac{B_{IF}}{f_{NP}} (C/N) \tag{5.3}$$

where

Θ_{max} = 1, the maximum permissible angular deviation

$(S/N)_{PM}$ = output signal-to-noise ratio after phase demodulation

5.2.3 Voice Communications

Voice signals will frequency-modulate a subcarrier, which, in turn, will phase-modulate the main carrier (FM/PM). The output signal-to-noise ratios are plotted in Fig. 5-11 against range for transmitter powers of 1 and 10 w. This voice link will probably be an FM/PM standard IRIG channel with a 3,700-cps frequency response and a subcarrier of 124 kc. The standard FM deviation is 15 percent.

5.3 MSN MISSION COVERAGE

Currently, there are seven land-based ground stations and three ships equipped for reception of telemetry, voice, and television data. Communication between the

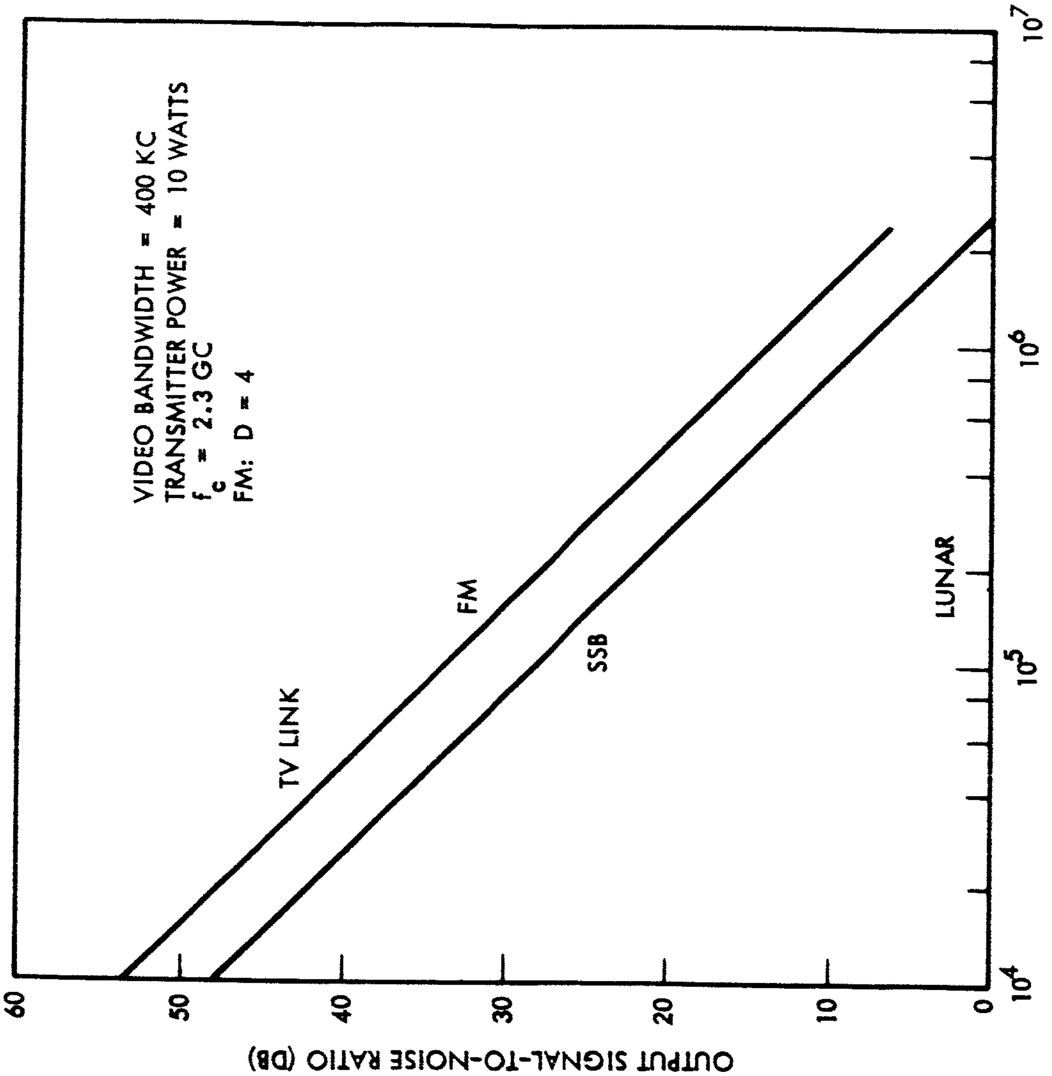


Fig. 5-10 Comparison of SSB and FM TV for Lunar and Deep-Space Missions (Analog Data)

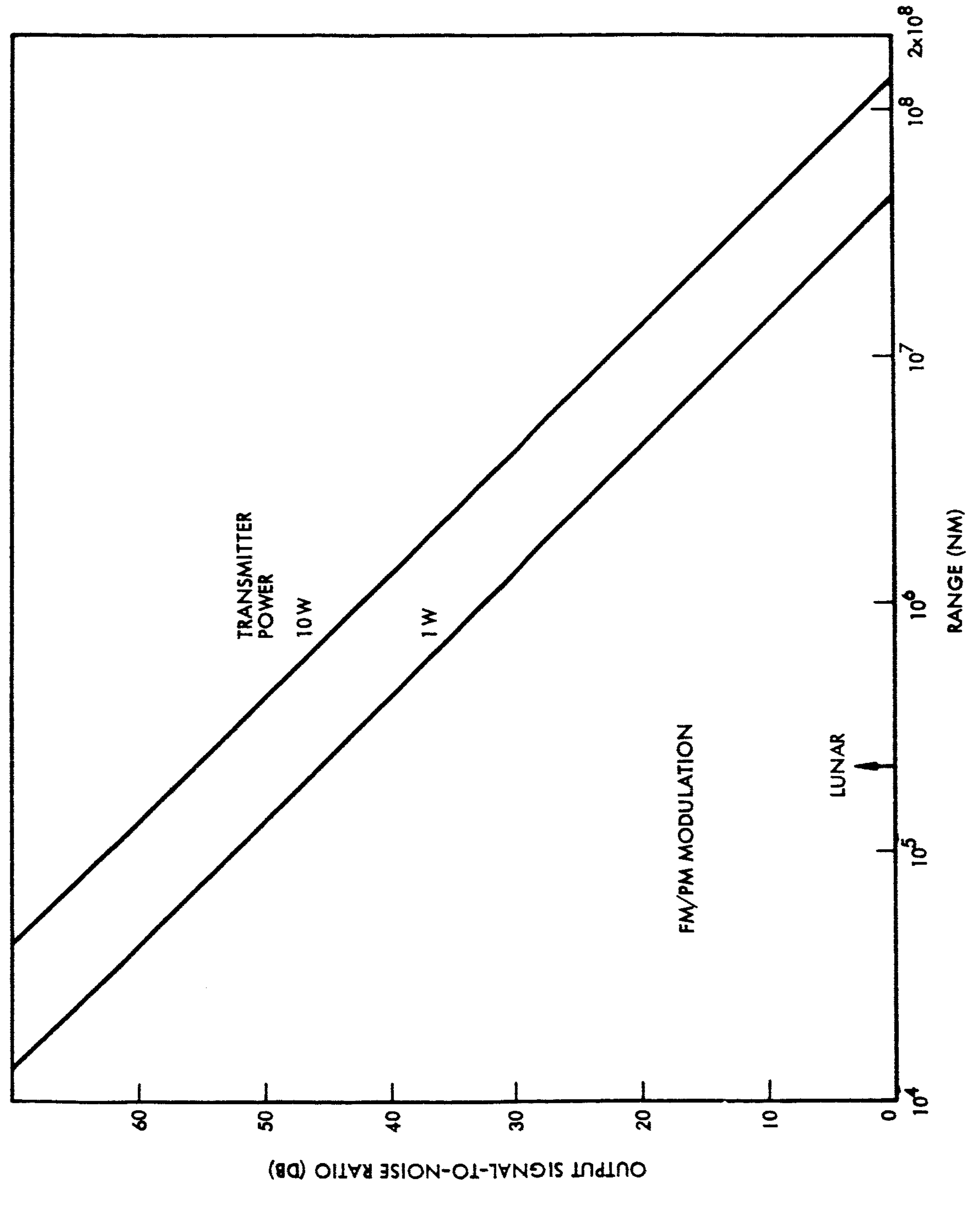


Fig. 5-11 Signal-to-Noise Ratios for Deep-Space Voice Links

vehicle and any one ground station can occur only when the vehicle passes in the line of sight of the ground station; the vehicle may be in contact with one or more of the ground stations. The frequency and duration of this contact depend on the altitude of the satellite. The higher the satellite, the longer and more frequent is its contact with the ground-station network.

The maximum time between readouts was estimated by means of coverage circles for each ground station mapped onto a large globe. Each ground station was the center of a series of concentric circles, each circle being the geocentric projection of the area of coverage of the ground station for a vehicle in orbit at a given altitude. The intersection of the ground track of the orbit (satellite path projected geocentrically on the globe's surface) with a given circle gives the limits of line-of-sight contact between the vehicle and ground station at the corresponding altitude. Although a circular orbit is assumed when the coverage areas are circular, the maximum time between readouts can be estimated for eccentric orbits if one considers the circular orbit drawn through the perigee. Every point in the eccentric orbit is farther from the earth's surface than any point in the circular orbit. Therefore, all coverage angles calculated for the circular orbit are a lower limit to those of the corresponding eccentric orbit. The maximum time elapsed between successive readouts can then be computed from the coverage-angle data.

The graph in Fig. 5-12 presents the results of this estimation for different angles of inclination of the orbit. For each inclination angle, the maximum time between readouts is plotted against the altitude of the orbit perigee. Only these seven land-based ground stations that can receive telemetry are considered: Cape Kennedy, Florida, Bermuda; Grand Canary Island; Carnarron, Australia; Hawaii; Guaymas, Mexico; and Corpus Christi, Texas.

The optimum inclination angles for this ground network are between 30 and 50 deg. These angles yield the longest contact time between the satellite and the ground

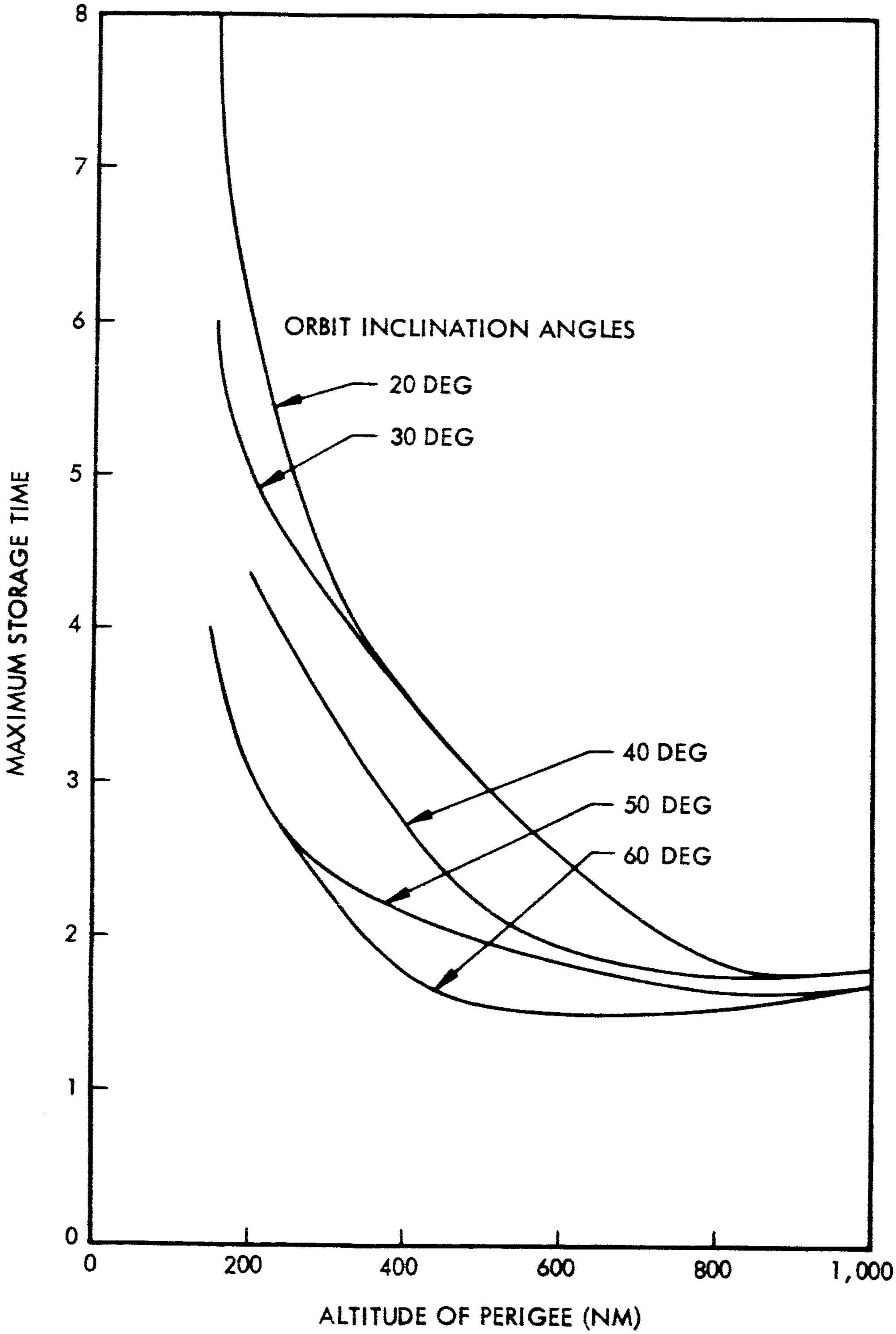


Fig. 5-12 Storage Requirements for Near-Earth Orbits, Using Land-Based Ground Stations

network. The geocentric coverage angles for 38-deg inclination are tabulated in Table 5-1 as a function of the longitude of the ascending node and altitude. The orbits giving the worst coverage for inclinations of 20, 30, 50, and 60 deg are presented in Table 5-2. Proper location of the instrumented ships will eliminate the large gaps in this coverage.

5.4 REPRESENTATIVE EXAMPLES OF DATA USAGE

In using the tables and figures described in this section, the designer of the data handling system will find himself constrained not only by the bit capacity of existing ground equipment, and the coverage ratio of the proposed orbit, but also he will find it highly desirable to use transmitters and antennas of existing designs. The constants given in Figs. 5-2 through 5-6 were selected on the basis of existing designs, and the curves shown in the figures can be used to determine whether existing equipment is adequate for the postulated mission.

Assume a mission as follows:

- Three man crew complement
- Near-earth orbit, with ships placed so that with radio range of 2,000 nm, contact can be maintained 5 hr of each 24-hr day.
- A payload (experiment) aboard, which requires transmission of a total of 1.8×10^{11} bits of data to earth, with a tolerable error rate of 1 in 10^5.
- Video and audio are required whenever data are transmitted.
- With these requirements, we can calculate the housekeeping data required in addition to the experimental data; calculate the mission duration; and determine the required sizes of transmitter, antenna, and video and audio equipment.

Table 5-1

TOTAL GEOCENTRIC ANGULAR COVERAGE FOR DIFFERENT ORBITS AT 38-DEG INCLINATION*

Longitude of Ascending Node	Altitude (nm)				
	150	200	500	800	1000
0°	–	–	–	–	24
15°E	–	–	28	49	58
30°E	0	21	43	59	65
45°E	25	29	49	62	69
60°E	19	26	47	139	153
75°E		15	74	91	102
90°E	16	24	88	105	116
105°E	32	37	102	154	176
120°E	44	50	148	179	197
135°E	65	119	166	197	213
150°E	95	113	176	205	233
165°E	105	121	202	234	250
180°	92	109	204	231	249
165°W	35	62	210	239	257
150°W	83	105	174	232	247
135°W	94	112	175	195	217
120°W	87	103	167	200	212
45°W	21	28	49	61	69
30°W	–	11	42	57	65
15°W	–	–	–	34	47

*Land-Based Ground Stations

Table 5-2

GEOCENTRIC COVERAGE ANGLES FOR
WORST ORBITS*

Inclination Angle (deg)	Longitude of Ascending Node	Altitude (nm) 150	200	500	800	1000
20	75°W	0	15	65	145	169
	60°W	–	0	41	85	149
	45°W	–	–	33	51	86
	30°W	–	–	0	43	52
	15°W	–	–	–	35	48
	0°	–	–	–	29	60
	15°E	–	–	19	44	54
	30°E	–	–	36	54	62
	45°E	9	21	42	59	66
30	60°W	17	25	49	93	115
	45°W	–	14	41	58	65
	30°W	–	–	37	55	64
	15°W	–	–	–	36	57
	0°	–	–	–	19	67
	15°E	–	–	24	53	56
	30°E	0	17	41	57	64
	45°E	21	27	46	61	66
50	30°W	16	23	46	60	66
	15°W	–	–	35	51	60
	0°	–	–	–	55	77
	15°E	–	–	35	53	61
	30°E	20	27	47	61	68
60	30°W	24	30	49	61	69
	15°W	–	0	39	55	62
	0°	–	–	0	68	90
	15°E	–	14	40	56	63

*Land-Based Ground Stations

Because of the large amount of experimental data to be transmitted, we shall attempt to use the Manned Spaceflight Network to its maximum capacity whenever we are within the 2,000-nm range. Calculating the number of bits that we can transmit per day:

$$1 \times 10^6 \text{ bits/sec (capacity of network)} \times 60 \text{ sec/min} \times 60 \text{ min/hr} \times 5 \text{ hr available transmission time per day} = 1.8 \times 10^{10} \text{ bits per day.}$$

From Table 3-1 we find that physiological status (operational mission) will require 2×10^6 bits/day/man, $\times$ 3 men = 6×10^6 bits/day, and that environmental data will require another 2×10^6 bits per day. These figures are very small in comparison with the 1.8×10^{10} bits per day available, and can be neglected in our calculations.

To accumulate the required data, we find that 10 days will be required:

$$1.8 \times 10^{11} / 1.8 \times 10^{10} \text{ bits per day} = 10 \text{ days}$$

From Fig. 5-2, which postulates a 1-w transmitter and a 0-db antenna gain, we find, by reading up from the 2,000-nm point to the "ground station capacity" line, that an error rate of 10^{-6} can be obtained. This is in excess of our requirement of 10^{-5}.

A check of Fig. 5-3 confirms our result, for moving up from the 2,000-nm point to its intersection with a horizontal line from our 10^6 bits/sec rate shows this intersection below the 0-db antenna line. The 0-db antenna is therefore satisfactory. But a -10-db antenna would not be satisfactory, since at 2,000 nm, the -10-db antenna line projects onto the vertical axis at less than 2×10^5 bits.

Similarly, Fig. 5-4, which shows the effects of increasing and decreasing transmitter power, indicates that the 1-w transmitter is adequate for 10^{-6} error rate at 2,000 nm; the data also demonstrate the inadequacy of smaller transmitters. The 1-w transmitter with 0-db antenna thus represents conservative design.

Figure 5-5 displays output signal-to-noise ratio for video links with various transmitters as a function of range. If, as specified in the problem, we require a 26-db S/N at 2,000 nm, we can determine the required power by going up from the 2,000-nm point to its intersection with the 26-db quality line. This indicates, conservatively, that a 10-w SSB transmitter or a 5-w FM transmitter will be adequate for our purposes.

Using Fig. 5-6 similarly to determine power requirements for the voice link, we find the 3-w UHF transmitter marginally adequate, while the 5-w HF transmitter is inadequate. The designer at this point can determine whether he can tolerate the performance of the 3-w UHF transmitter, or whether he should use voice powers in excess of those listed in Fig. 5-6.

In Deep Space missions, a different set of constraints will control the data systems design. Only one transmitter will be used, for PCM, audio, and video combined; and in all cases a compromise solution to the data handling problem must be made among transmitter power, antenna complexity, tolerance of bit error, complexity of error correcting coding, and complexity of the data handler itself (data-compression capability).

Figure 5-7 illustrates the desirability of increasing the system's tolerance of error; approximately 1.8 times as many bits can be transmitted a given distance if error tolerance is increased from $1/10^5$ to $1/10^3$ (Draw a vertical line intersecting the three error-tolerance curves and project the intersections on the vertical axis. The values on the vertical axis as projected from the $1/10^3$ line and the $1/10^5$ line are in ratio 1.8/1). Figure 5-8 shows the effect of increased antenna capability; every increase of 10 db in antenna effectiveness increases the bit rate by a factor of 10 (note that the intersections of the antenna gain lines with the vertical axis are in ratio 10/1). Similarly, a projection of a vertical line's intersections with the power lines of Fig. 5-9 shows bit rate to be a linear function of power.

To determine the various parameters for a particular mission, a calculation should first be made of the required "housekeeping" and environmental bits as given in Table 3-2. With a three-man crew on extended mission, housekeeping will require

5×10^3 bits/sec/man $\times$ 3 men $= 1.5 \times 10^4$ bits/sec, max, and

2×10^6 bits/day/man $\times$ 3 men $= 6 \times 10^6$ bits/day, while environmental data will require 5×10^4 bits/sec max and 10^7 bits per day. Totals are

6.5×10^4 bits/sec, max, and

1.6×10^7 bits per day

The bits/sec max figure is the more constraining one in this case, for, if our transmission link can meet this requirement, it can transmit the entirety of the housekeeping and environmental data in a little over 4 min and have the rest of the day to transmit mission-connected data.

Figures 5-8 and 5-9 can be used to calculate maximum distances for the 6.5×10^4 bit rate for various antenna gains and powers. Drawing a horizontal line from the 6.5×10^4 point on the vertical axis, we find, from Fig. 5-8, that with a 10-w transmitter and reasonable receiving equipment on earth, our transmission distance for various antennas is

10 db : 2.5×10^5 nm
20 db : 8.0×10^5 nm
30 db : 2.5×10^6 nm
40 db : 8.0×10^6 nm

Similarly, from Fig. 5-9, with a 26.7-db antenna aboard the vehicle, our distance with various transmitters is

1 w : 5.5×10^5 nm
10 w : 1.7×10^6 nm
100 w : 5.5×10^6 nm
1000 w : 1.7×10^7 nm

If the mission involves carrying the three-man crew more than 10^7 nm from earth (that is, beyond Mars' orbit), we find that either a very large antenna (40 db) or a very large transmitter (1,000 w) will be required unless special data-handling provisions are made aboard the vehicle. Data compression is indicated in such cases.

Section 6
DATA SYSTEMS

Six levels of data system complexity have been identified for biological space missions (in actuality, essentially the same levels are identifiable in all space missions). The first two levels, audio-visual and a standard PCM system, are well within the state-of-the-art, and have been used in some form in prior missions. A great deal of information is now being accumulated on the expected performance of Syntactic Data Compressors (Level 3), in which redundancy is removed from the various wavetrains and only significant data points are transmitted, "redundancy" and "significance" having been calculated according to some algorithm.

To satisfy future mission requirements, more complex systems will be required, and mission success will depend on the design of the higher level systems. In Pragmatic Compression (Level 4), decisions are made by the data handling system as to the significance of the various waveforms, and transmissions are made accordingly. In Semantic Compression (Level 5), data from the various channels are combined so as to generate a descriptor of an event, and this descriptor is transmitted. Diagnostic units (Level 6) are capable of analyzing the significance of events and generating commands for remedial action. The use of such units will reduce the necessity for the transmission of routine or "housekeeping" data to the vanishing point.

Figures 6-1 through 6-4 show block diagrams of data systems incorporating these features. Figure 6-1 presents a basic PCM system. Each succeeding figure includes more sophistication and complexity, until a complete system is attained as shown in Fig. 6-4. Along with each block diagram is indicated the mission type for which the system is deemed best suited. Figure 6-5 is included to show the elementary functions of multiplexing, analog-to-digital conversion, and syntactic compression, which are fundamental elements upon which the more complex systems are built.

Table 6-1
DATA FOR POSTULATED SYSTEMS

System	Relative Data Rates of Output (bits/sec)	A Priori Information Required	Probable Relative Weight (lb)	Probable Relative Power (w)	Status of Development
1. Audio-Visual		None or A			A Off the shelf hardware available
2. PCM	10^7	A, B	20	20	B Thoroughly studied; specialized hardware usually required, procurable on fixed-price basis
3. Data Compression	3×10^5	A, B	30	30	C Systems under intensive study; some specialized hardware in operation; generalized hardware possible; improvements in design philosophy expected
4. Pragmatic Compression	5×10^2	A, B, C, D	35	35	D Some systems work done; more study indicated, which will improve system performance; individual study of cases required to tailor system to the application
5. Semantic Compression	5×10	A, B, C, D, E	45	45	E Study work rudimentary, and has been applied to only a very few types of data; intensive study required before practical devices can be contemplated
6. Diagnostic	10	A, B, C, D, E	70	70	F Virtually no prior art; preliminary study work necessary to determine requirements for studies pointing the way to practical hardware; some specialized hardware capable of being built with present knowledge

A priori information required:

A. Knowledge of instruments required

B. Dynamic ranges and frequency responses of measured phenomena required

C. Priority arrangement required among the various channels

D. Detailed knowledge of waveforms to be expected required,

E. Significance of waveforms required; preprogrammed means of establishing normality and departures from it, as well as causative factors for abnormalities

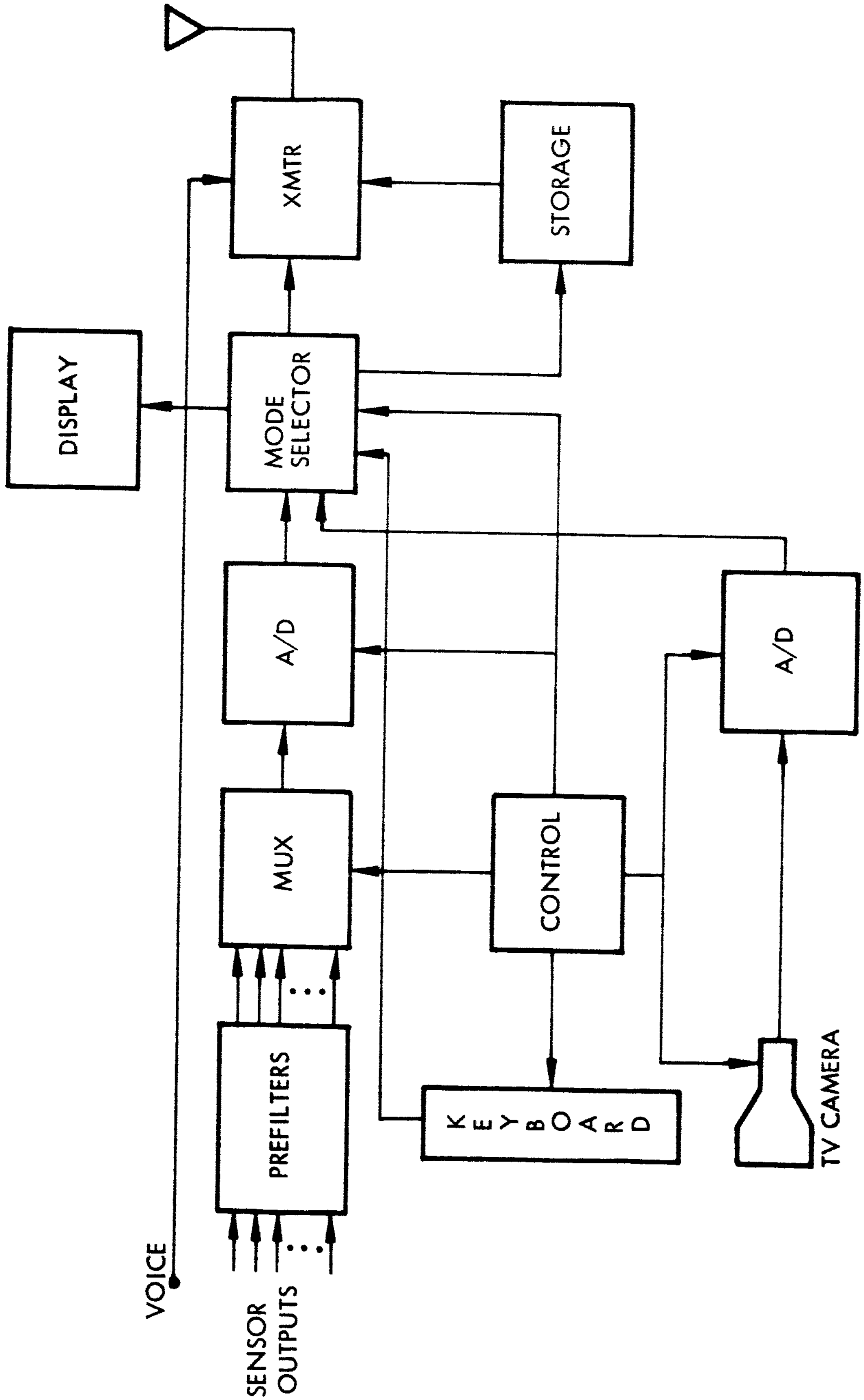


Fig. 6-1 Basic PCM Telemetry System With Mission Adjuncts

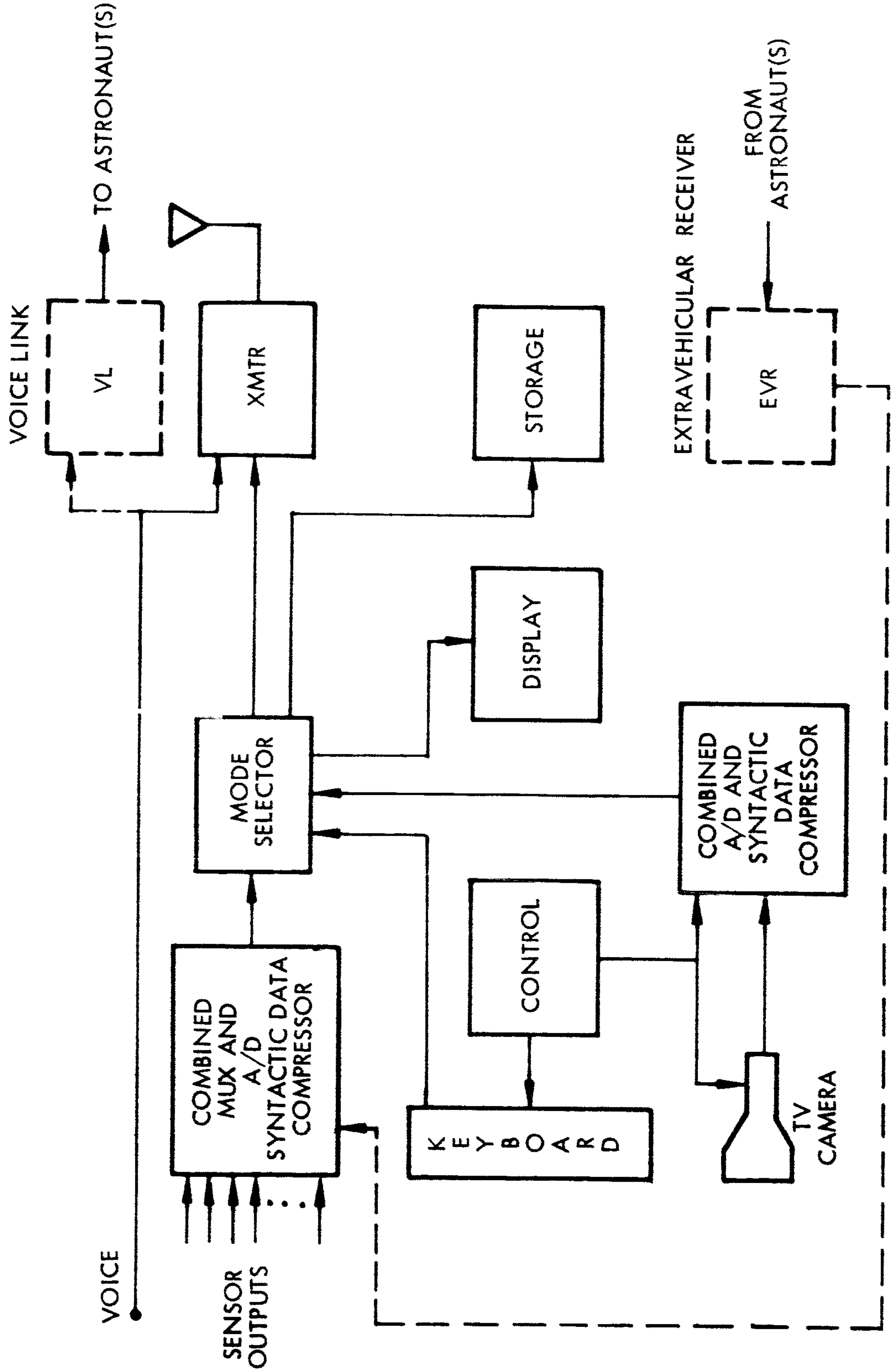


Fig. 6-2 Data Management System for Near-Earth Orbit

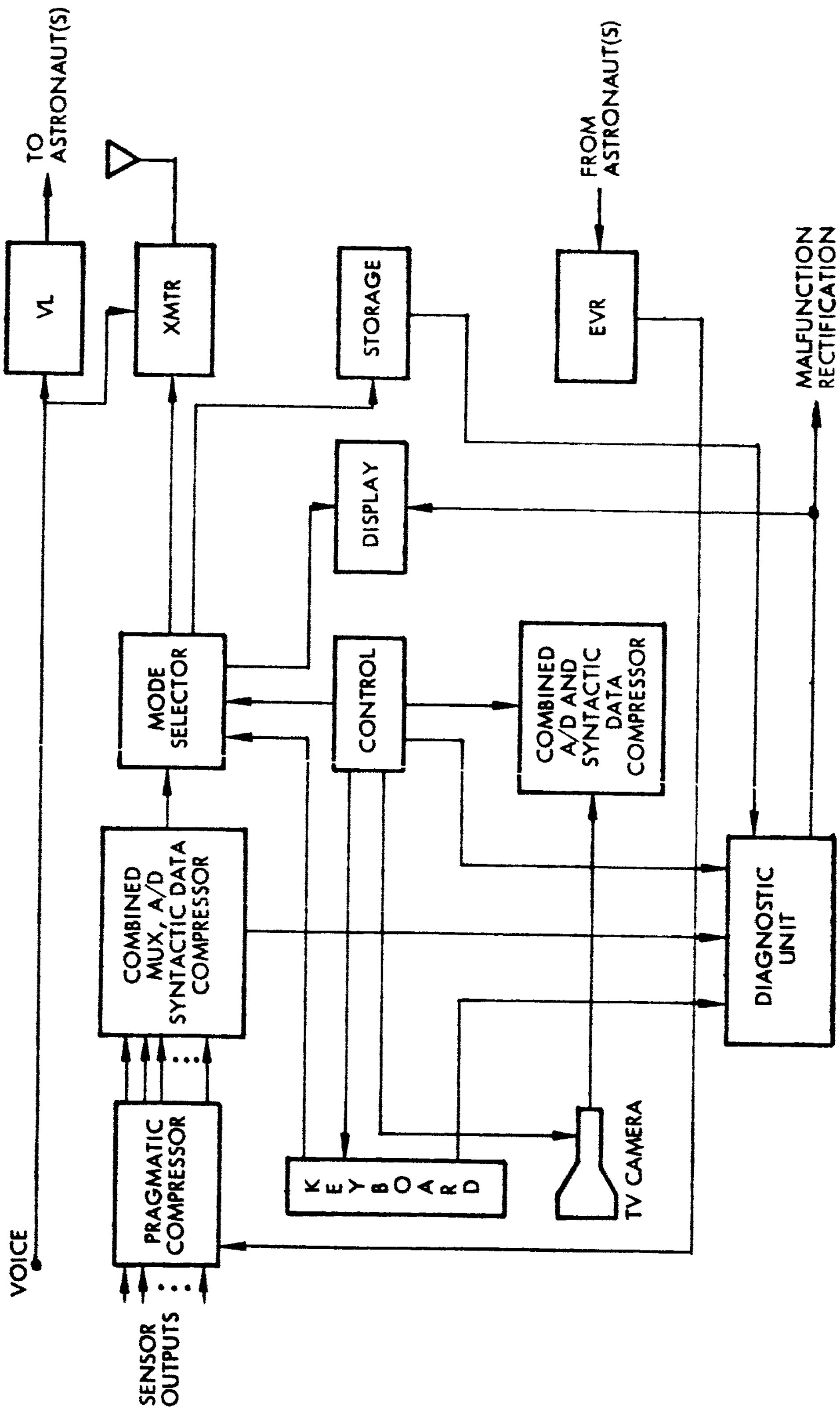


Fig. 6-3 Data System for Lunar Mission

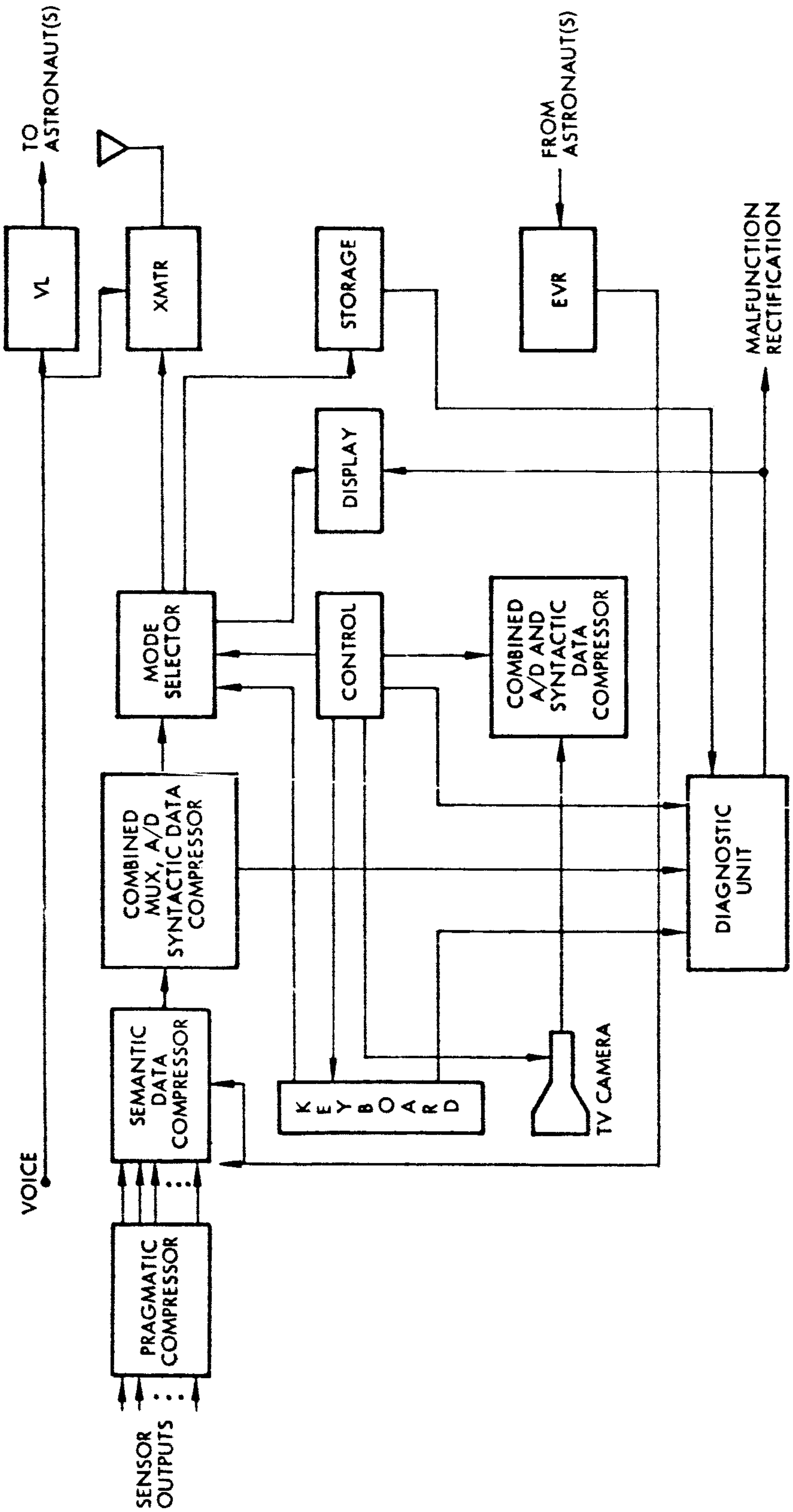


Fig. 6-4 Data System for Planetary Mission

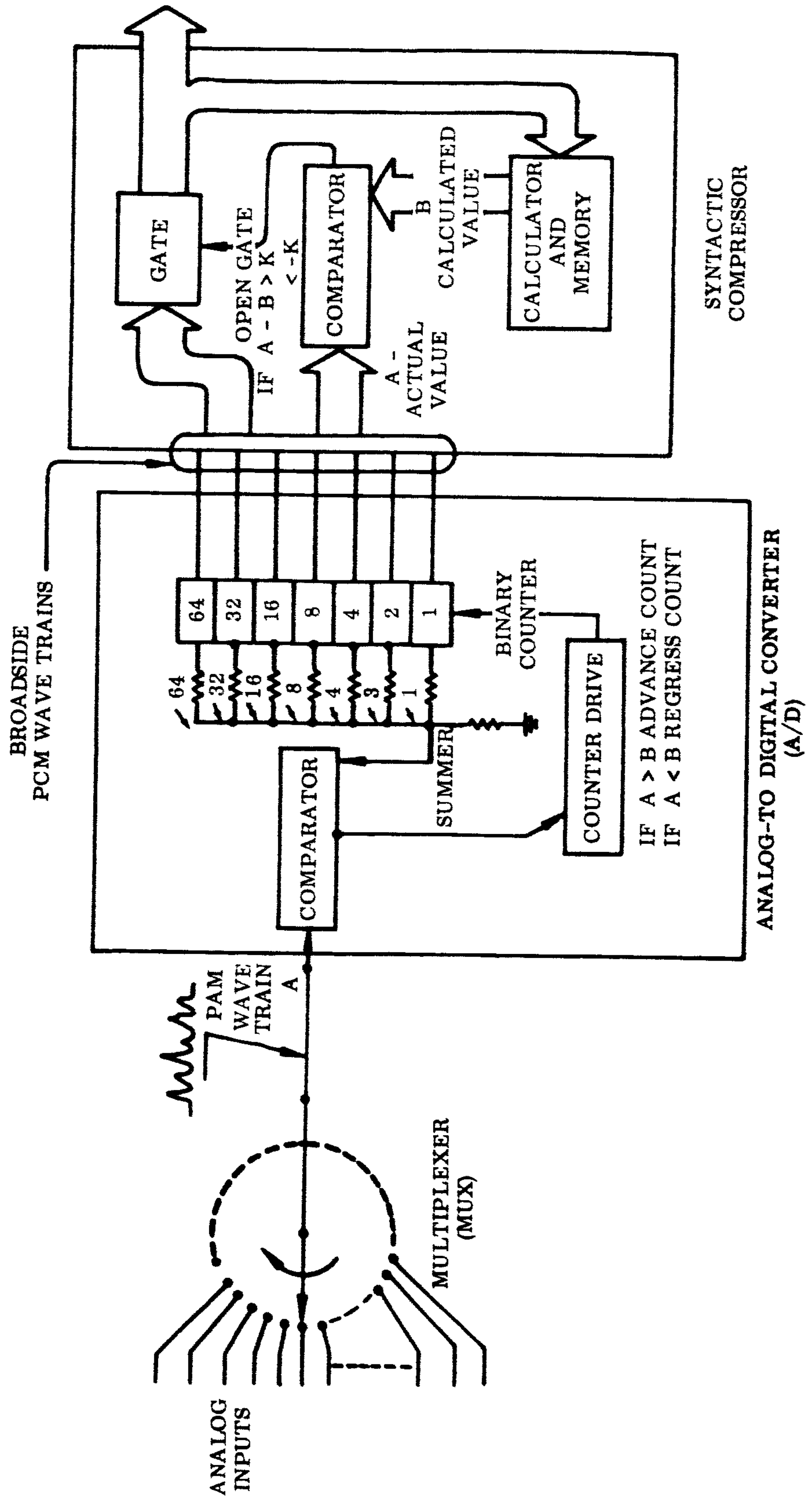


Fig. 6-5 Multiplexer Quantizer Compressor Block Diagram

The tables and figures in this section should prove useful for planning purposes and gross estimation of data-system characteristics for future biological missions.